TRANSACTIONS AND PROCEEDINGS

OF THE

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PART IV.

SESSION 1953-54.

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PROCEEDINGS

OF THE

BOTANICAL SOCIETY OF EDINBURGH

SESSION CXVIII

OCTOBER 15, 1953.

Dr. J. M. Cowan, President, in the Chair.

The following Office-Bearers were elected for Session 1953–54:

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The TREASURER, Mr. J. W. H. JOHNSON, C.A., submitted the following Statement of Accounts for Session 1952–1953:

INCOME.

Annual Subscriptions for 1952–1953	£88 15 0
Arrears of Subscriptions recovered	23 0 0
Transactions sold	42 9 1
Interest on Invested Funds	23 6 1
Subscriptions to Publications Fund	6 13 4
Income from Botanical Society Trust Fund	11 11 0
Income Tax recovered	17 13 8
Grant from Carnegie Trust	100 0 0
Balance of Excursion Fund	2 14 6
	£316 2 8
Excess of Expenditure over Income	53 11 2
	£369 13 10

EXPENDITURE.

Printing *Transactions*, Vol. 36, part 2	£274 15 9
Printing and Postages of Notices for Meetings	72 1 4
Stationery, Postages, etc.	12 6 9
Fire Insurance on Books	0 5 0
Honorarium to Treasurer	5 5 0
Honorarium to Assistant Secretary	5 0 0
	£369 13 10

STATE OF FUNDS.

Life Membership Fund.

Balance at close of Session 1951–1952	£1000	0	0
Add—Life Compositions received in 1952–1953 . .	6	6	0
Donation received in 1952–1953	3	0	0
Premium on Conversion of 3% Defence Bonds .	1	0	0
	£1010	6	0
Less—Transferred to Ordinary Fund	37	8	5
	£972	17	7

Ordinary Fund.

Balance at close of Session 1951–1952 .	£16	2	9			
Add—Transferred from Life Membership Fund	37	8	5			
	£53	11	2			
Less—Deficiency for year . .	£53	11	2			
Being:—£200 3½% War Stock at cost .	£194	18	3			
£258, 2s. 6d., British Transport 3% Guaranteed Stock 1978–88 at cost . . .	216	18	6			
£100 3% Defence Bonds at cost	100	0	0			
£100 3½% Defence Bonds at cost	100	0	0			
£250 3% Savings Bonds 1965–75 at cost	253	18	3			
Sum on Current Account with Clydesdale and North of Scotland Bank Ltd. . . .	116	7	7			
	£982	2	7			
Less—Subscriptions received in advance	9	5	0			
				£972	17	7

EDINBURGH, 11*th September* 1953.—I hereby certify that I have audited the Accounts of the Treasurer of the Botanical Society of Edinburgh for the Session 1952–1953, and have found them correct. I have also checked the foregoing Abstract and found it correct. I have seen the securities for the invested funds and found them in order.

CHARLES A. SCOTT, C.A., *Auditor*.

SIR WILLIAM WRIGHT SMITH LECTURESHIP FUND.

SESSION 1952–1953.

Donations received				£289	12	6
Less—Expenses				8	13	6
Balance of Fund at close of Session				£280	19	0
Being:—£250 3½% War Loan at cost	£203	12	0			
On Savings Account with Union Bank of Scotland Ltd.	77	7	0			
				£280	19	0

EDINBURGH, 11*th September* 1953.—I hereby certify that I have audited the Accounts of the Sir William Wright Smith Lectureship Fund for the Session 1952–1953, and have found them correct. I have seen the securities for the invested funds and found them in order.

CHARLES A. SCOTT, C.A., *Auditor.*

Professor A. R. CLAPHAM delivered the First Wright Smith Lecture. His subject was: "Weeds of Mountain and Loch-side."

NOVEMBER 12, 1953.

Dr. J. A. MACDONALD, Vice-President, in the Chair.

The meeting took the form of a Symposium on Recent Work on the British Flora.

The following papers were read:

1. "A New Subspecies for Britain," by P. S. GREEN, B.Sc.
2. "The Problem of *Hypericum humifusum* L. and its Allies," by N. K. B. ROBSON, B.Sc.
3. "The Growing of Euphrasias," by D. A. WILKINS, B.Sc.
4. "Records of Lothian Plants," by H. H. DAVIDIAN, B.Sc.

DECEMBER 10, 1953.

Dr. W. BURNS, President, in the Chair.

Dr. M. E. ACHESON and Dr. R. T. HUNTER were elected Ordinary Fellows.

Mr. E. B. BASDEN was elected an Ordinary Member.

Mr. A. H. H. ROSS read a paper entitled "Aspects of Afforestation in Scotland," and exhibited a film on the Afforestation of the Culbin Sands.

JANUARY 14, 1954.

Dr. W. BURNS, President, in the Chair.

Mr. J. A. D. NIMMO was elected an Ordinary Fellow.

The following papers were read by title:

1. "A First List of the Fungi of Zetland (Shetland)," by R. W. G. DENNIS and ELIZABETH G. GRAY. (See xxxvi, 215.)
2. "Pollen Analysis of a Peat at Kingsteps Quarry, Nairn," by ELIZABETH M. KNOX. (See xxxvi, 224.)
3. "Notes on Some Uncommon Algae from Lochs in the Tummel-Garry Catchment Area," by A. J. BROOK.(See xxxvi, 207.)

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TRANSACTIONS

OF THE

BOTANICAL SOCIETY OF EDINBURGH

SESSION CXVIII

VITAMIN CONTENT OF ARCTIC PLANTS. PART III.

By KAARE RODAHL.
(Arctic Aeromedical Laboratory, Fairbanks, Alaska, and
Institute of Physiology, Oslo University, Norway.)

(Read by title, 18th November 1954.)

In two previous publications (Rodahl, 1944, 1945) the results of vitamin C and vitamin B_1 determinations in some common arctic plants were reported. The present paper represents a continuation of the above-mentioned studies, including an attempt to analyse the significance of arctic plants in human nutrition.

It is well known that plants have been used by man for food in northern countries from time immemorial. Apparently certain plants and the stomach contents of herbivorous animals formed an important part of the diet of the Stone Age man (Reichborn-Kjennerud, 1936). In Norway, angelica, scurvy grass, mountain sorrel and roseroot were eaten as invigorating foods from the earliest times, and have been used as a cure for scurvy (Reichborn-Kjennerud, 1936). According to Ehrström (1933), the Lapps use berries, sorrel, angelica and scurvy grass. A great variety of plants as well as seaweeds played an important part in the original Eskimo diet, although the use of plants as food has steadily declined in the Eskimo communities since the contact with the white man. Thus, as early as in 1770, only half a century after the arrival of the first missionary, the use of plant food was markedly reduced in West Greenland (Bertelsen, 1911).

According to Höygaard (1941) nearly all land plants and berries are still eaten by the Angmagssalik Eskimo, but only a few species which grow abundantly are eaten in sufficient quantities to be important as a source of food, viz. crowberries, roseroot, willow, mountain sorrel, thyme, saxifrage, harebell, dandelion, scurvy grass and angelica. These plants may be eaten when collected, or they may be brought to the house or tent, where they are eaten together with blubber or dried meat, or stored in blubber bags, together with dried meat, boiled seal flippers, boiled narwhale skin, fat and dried marine algae.

Marine algae are consumed in quite large quantities by the East Greenland Eskimos, who usually eat them raw after rinsing in fresh water. Sometimes they are dipped in boiling meat stock until they take a greenish colour, or they are eaten with blubber oil. *Alaria pylaii* and *Rhodymenia palmata* are the more important species. The use of *Rhodymenia palmata* as human food is well known in Iceland, and this alga is repeatedly mentioned in the sagas. It is also known that marine algae have been used as food in Japan, China and Hawaii.

The Eskimos on the north-west coast of Greenland no longer consume berries and plants to any extent of nutritional importance. Small quantities of *Empetrum nigrum* are eaten on rare occasions in autumn. The same applies to *Oxyria digyna* and to the bark from willow roots. *Cochlearia* is no longer eaten, nor is the stomach content of herbivorous animals.

In the Disco Island district large quantities of *Empetrum nigrum* and *Vaccinium uliginosum* are still consumed raw. The same applies to the Julianehaab district, where the kajak hunters also occasionally consume marine algae mixed with blubber during the hunting in the summer.

According to Porsild (1945) the Canadian Eskimo to-day obtains a very insignificant part of his food from the vegetable kingdom, although some plants are normally consumed, such as the liquorice-root (*Hedysarum boreale*), which they sometimes obtain by robbing the winter caches of mice and lemming.

In Alaska close to one hundred various plants have been used as food by Eskimos and Indians through the ages. Since the contact with the white man the use of native plant food has rapidly been reduced also in Alaska. However, some land plants and berries are still being used to-day in most settlements along the Arctic Coast. Of greatest importance are the different berries, such as the blueberries, cranberries, crowberries and salmonberries. At Gambell, St. Lawrence Island, willows are gathered for the edible root bark and occasionally for the tender leaves, as well as *Sedum roseum* (Nonavook), *Petasites frigida* (Kongwak) and *Saxifraga punctata*

(Amslokruk). The roots of various other plants are also gathered for food, particularly when found in the underground cache of field mice, where according to Geist and Rainey (1936) half a bushel of choice roots sometimes may be found in a single cache. At Gambell the plants to be prepared for winter use are usually gathered by the women in the month of July. The plants including stem and leaves are usually washed prior to being placed in wooden barrels. Fresh water is added, and heavy weights are placed on top. The barrel is left standing until the plants become slightly sour, and when frost appears most of the water is discarded. The plants are then stored frozen, to be consumed in the winter together with meat and blubber.

Of other plants still being consumed at various settlements by the natives in Alaska, the following may be mentioned: *Hedysarum alpinum* (Eskimo potato), *Epilobium latifolium*, *Oxyria digyna*, *Angelica lucida*, *Cochlearia officinalis*, *Rumex arcticus* and *Ledum palustre* (Labrador tea). Of particular interest is the "Eskimo ice-cream", prepared in the following way on the west coast of Alaska: Leaves of a mixture of plants including *Arenaria peploides* are ground and thoroughly mixed with seal oil, walrus oil or caribou fat, whipped and left in a cold place to freeze. Sometimes berries are added. The "ice-cream" is eaten by itself as a dessert.

As pointed out by Porsild (1951), the wild plant life in the arctic regions is generally too sparse, dwarfed and poorly developed to make any major contribution to the food supply of man under the present climatic conditions. Only a few of the arctic plants produce edible and nourishing roots and stems or edible fruits. It is thus obvious that plants could not be depended upon as a major source of food supply in arctic survival. Nevertheless, arctic plants have been used as food supplements by arctic travellers and are mentioned in their reports.

This is also true of lichens, which produced the biblical "rains of manna" of the Israelites (possibly the lichen *Lecanora esculenta*, which according to Llano (1951) is still eaten by desert tribes), and which were used as emergency food for many weeks by the marooned party of Sir John Franklin in the region north-west of Hudson Bay. They lived on the dry, black, tough lichens of the genus *Gycophora* (Tripe de Roche), which grows on precambrian rock (Fernald and Kinsey, 1943). When dry it is hard and brittle, but in damp weather it becomes soft and cartilaginous and is then easily collected. It contains an acid which is bitter and may cause intestinal irritation. According to Porsild (1945), this acid is materially reduced by adding small amounts of alkali to the water in which the lichens are soaked. Following the soaking, the lichens are dried until brittle, after which they are made into a powder by rubbing or pounding. The powdered lichen is then soaked in water overnight, and when boiled, a jelly is formed which is rich in starch.

In his diary Sir John Franklin describes how this lichen saved his party from starvation until the lichen became so frozen that it could no longer be collected, when he wrote in his journal: "The tripe de roche had hitherto afforded us our chief support, and we naturally felt great uneasiness at the prospect of being deprived of it, by its being so frozen as to render it impossible for us to gather it."

According to Llano (1951) lichen has not only been used as a last resort in the face of starvation, but also as a delicacy, *e.g.* the use of *Cetraria islandica* (Iceland moss) in Iceland, Norway and Sweden.

Very little exact information is available regarding the actual nutritional value of arctic plants. Höygaard (1941) reports that marine algae (*Fucus* sp., *Alaria pylaii*, *Rhodymenia palmata* and *Ascophyllum nodosum*) contained on an average 81–85 per cent. water, 1·6–2·4 per cent. protein, 0·1–0·4 per cent. fat, 9·6–14·9 per cent. carbohydrate, 117–189 mg. calcium, 20–60 mg. phosphorus and 1330–1580 mg. sodium chloride per 100 gm. *Sedum roseum* contained 93·9 per cent. water, 2·1 per cent. protein, 0·4 per cent fat, 2·5 per cent. carbohydrate, 70 mg. calcium, 22 mg. phosphorus and 131 mg. sodium chloride per 100 gm. The figures for crowberries (*Empetrum hermaphroditum*) were: 89·2 per cent. water, 0·2 per cent. protein, 0·1 per cent. fat, 10·0 per cent. carbohydrate, 8 mg. calcium, 7 mg. phosphorus per 100 gm. and very small amounts of sodium chloride. Vegetables stored in blubber bags for winter food contained 63·9 per cent. water, 1·1 per cent. protein, 23·7 per cent. fat, 10·5 per cent. carbohydrate, 98 mg. calcium, 32 mg. phosphorus and 162 mg. sodium chloride per 100 gm.

From these figures it is obvious that plants, in the quantities they are eaten by the Eskimos, are quite unimportant as a source of calories, since it would be necessary to consume approximately 10,000 gm. of fresh plant material to supply 2000 calories. It would take 4000 gm. of seaweed or berries, or 700 gm. of plants stored in blubber bags, to supply the same amount of calories. Höygaard (1941) reports that in Angmagssalik, South-east Greenland, the native vegetable food supplied only 2 per cent. of the total caloric intake of the Eskimo.

Compared with the rich animal sources of vitamin A available to

TABLE I.

VITAMIN C CONTENT OF SOME COMMON GREENLAND PLANTS EXAMINED AT NORTH-EAST GREENLAND, LAT. 74° N.

Plant.	Part of Plant Analysed.	Date of Analysis.	Mg. Ascorbic Acid per 100 gm.	
			Mean.	Range.
Alaria sp.	Whole plant	Sept. 7–16	5	4–7
,, ,,	Roots and stems	,, 16	16	12–21
Alopecurus alpinus	Whole plant	,, 13	40	37–44
,, ,,	Leaves	July 29	84	62–105
,, ,,	Stems	,, 29	39	32–46
Armeria vulgaris	Leaves	,, 22	165	128–195
,, ,,	Stems	,, 22	120	105–135
Arnica alpina	Leaves	,, 11	5	. .
,, ,,	Stems	,, 11	4	. .
Betula nana	Buds	May 1–June 4	30	9–50
,, ,,	Leaves	July 2–Aug. 1	209	198–232
,, ,,	Stems	May 1–Aug. 1	10	8–14
Cassiope tetragona	Whole plant	July 8	148	120–150
Cerastium alpinum	,, ,,	Sept. 13	42	42–42
,, ,,	Leaves	July 27	60	58–62
,, ,,	Stems	,, 27	32	31–34
Dryas octopetala	Whole plant	June 24	243	. .
,, ,,	Stems	,, 24	200	. .
,, ,,	Flowers	,, 24	180	. .
Empetrum nigrum	Branches	Sept. 1	47	. .
Epilobium latifolium	Leaves	July 17	132	132–132
Eriophorum callitrix	Whole plant	Aug. 30–Sept. 15	3	2–4
Fucus sp.	,, ,,	Sept. 16–Nov. 16	9	3–17
Honckenya peploides	Flowers	July 30	74	. .
,, ,,	Leaves	,, 30	55	50–60
,, ,,	Stems	,, 30	15	. .
,, ,,	Whole plant	Apr. 30–Dec. 31	14	1–27
,, ,,	Buds	May 25–July 30	40	1–80
Koenigia islandica	Whole plant	July 27	180	. .
Lychnis triflora	Leaves	,, 20	94	80–108
Melandrium affine	Whole plant	,, 27	105	. .
Oxyria digyna	,, ,,	,, 27	95	. .
Papaver radicatum	,, ,,	Aug. 26–30	3	1–5
,, ,,	Leaves	July 6	6	4–9
,, ,,	Stems	,, 6	3	. .
,, ,,	Flowers	,, 7	7	6–7

TABLE I—*continued.*

Plant.	Part of Plant Analysed.	Date of Analysis.	Mg. Ascorbic Acid per 100 gm.	
			Mean.	Range.
PEDICULARIS HIRSUTA	Leaves	July 22	22	. .
POA GLAUCA	Whole plant	Sept. 13	12	11–12
POTENTILLA NIVEA	Leaves	July 12	314	295–330
RUMEX ACETOSELLA	Whole plant	Aug. 30	12	. .
SALIX sp.	Buds	Jan. 31–June 3	25	16–30
,, ,,	Stems	Mar. 29–July 31	46	22–63
,, ,,	Leaves	June 25–July 31	160	90–230
SAXIFRAGA CERNUA	Leaves	Aug. 2	86	80–92
,, ,,	Stems	,, 2	60	. .
SAXIFRAGA OPPOSITIFOLIA	Whole plant	June 10	54	. .
STELLARIA HUMIFUSA	,, ,,	Aug. 26	60	50–70
MUSHROOMS (3 species)	Whole fungus	Nov. 1–Sept. 25	1	0–2

the Eskimo (Rodahl, 1949), the plants are of comparatively little importance as a source of this vitamin. The vitamin B1 content of the common arctic plants is also insignificant (Rodahl, 1945).

On the other hand, determinations of the vitamin C content of arctic plants have shown that several of the plants common in the Arctic, as well as the marine algae collected from arctic waters, are extremely rich in vitamin C (Höygaard, 1941; Rodahl, 1944), as is evident from Tables I, II and III. This is not surprising in view of the fact that it has long been known that many arctic plants have been used as a remedy against scurvy in northern countries (Bartholin, 1671–72). In South-east Greenland the Eskimos obtain 50 per cent. of their total vitamin C intake from plants and seaweeds during the summer months (Höygaard, 1941), and in many cases it is observed that the plants which are preferred by the Eskimo have the highest vitamin C content. Furthermore, plants stored in blubber bags in the Eskimo manner have been found to contain considerable quantities of vitamin C even after having been kept in this way for months.

There are considerable seasonal variations in the vitamin C content of the plants examined, the highest values being found in

Table II.

Vitamin C Content of Some Common Greenland Plants examined at Pearyland, Lat. 82° N.*

Plant.	Part of Plant Analysed.	Mg. Ascorbic Acid † per 100 gm.
Alopecurus alpinus	Whole plant	170
Cerastium alpinum	,, ,,	85
Cerastium regelii	,, ,,	77
Chamaenerion latifolium	,, ,,	305
Cochlearia officinalis	,, ,,	149
,, ,,	Fruit	170
,, ,,	Stem	136
,, ,,	Root	68
Cystopteris fragilis	Whole plant	100
Draba sp.	,, ,,	100
Draba sp.	,, ,,	50
Dryas octopetala	,, ,,	135
Equisetum arvense	,, ,,	68
Erigeron compositus	,, ,,	34
Eriophorum callitrix	,, ,,	35
Glyceria sp.	,, ,,	60
Melandrium apetalum	,, ,,	119
,, ,,	Root	34
Minuartia rubella	Whole plant	100
Oxyria digyna	,, ,,	119
,, ,,	Fruit	205
,, ,,	Leaves	102
,, ,,	Stem	85
Papaver radicatum	Whole plant	50
Pedicularis hirsula	,, ,,	50
Poa glauca	,, ,,	50
Polygonum viviparum	,, ,,	100
Potentilla nivea	,, ,,	270
Potentilla rubricaule	,, ,,	145
Salix sp.	,, ,,	160
Saxifraga cernua	,, ,,	119
Saxifraga flagellaris	,, ,,	65
Saxifraga oppositifolia	,, ,,	50
Stellaria longipes	,, ,,	135
Taraxacum pumilum	,, ,,	34

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* All analyses were carried out between August 3 and 7.

† Average of 10 plants or more.

Table III.

Vitamin Content of Some Common Alaska Plants.*

Plants.	Part of Plant Analysed.	Mg. Ascorbic Acid per 100 gm.
Achillea borealis †	Whole plant	9
Alnus crispa †	Leaves, stalks, catkins	27
Alnus oregona	Buds	2
,, ,,	Leaves, stalks, catkins	20
Aster sibirica	Leaves, stems, flowers	14
Betula sp.	Leaves, stems	58
Brassica arvensis	Whole plant	145
Capsella bursa-pastoris	Whole plant	72
Carex stratiformis	,, ,,	51
Cassiope tetragona	,, ,,	225
Chamaenerion latifolium	,, ,,	18
Chenopodium album †	,, ,,	80
Chenopodium capitatum	,, ,,	129
Chondrus crispus	,, ,,	9
Cladonia amaurocrasa †	,, ,,	25
Cladonia rangiferina †	,, ,,	0
Cladonia timbriata †	,, ,,	0
Diapensia lapponica †	,, ,,	54
Duforea arctica	Leaves	18
Elephantella groenlandica	Roots	2
,, ,,	Stems, pods	16
Empetrum nigrum	Berries	81
,, ,,	Leaves	37
Eriophorum ocreatum	Stalks, flowers	13
Hylocomium splendens	Whole plant	14
Ledum groenlandicum	,, ,,	174
,, ,,	Leaves	278
Lupinus parviflorus	Leaves, pods, stalks	42
Lycopodium annotinum	Whole plant	18
Nostoc sp.†	,, ,,	0
Oxyria digyna	Leaves, roots	20
Pedicularis labradorica	Fruits, stems	0
Potentilla fruticosa	Whole plant	27
Pyrola grandiflora	Leaves, buds, roots	110
Ribes triste	Berries	79
Rosa nutkana	Hips	1404
,, ,,	Leaves, stalks, roots	36
Salix anglorum	Catkins, stalks, leaves	72

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* All analyses were carried out between September 16 and 25.

† Plants marked (†) were from Ladd Field; the others were from Rainbow Pass.

Table III—*continued.*

Plants.	Part of Plant Analysed.	Mg. Ascorbic Acid per 100 gm.
Salix sp.	Leaves	72
,, ,,	Buds	72
,, ,,	Catkins	36
,, ,,	Stems	26
Sedum roseum	Whole plant	99
Silene acaulis	,, ,,	160
Stetocaulontomen tibsum †	,, ,,	0
Vaccinium ovalifolium	Berries	63
Vaccinium vitis idea	Berries	108
,, ,, ,,	Leaves, roots	23
Viburnum pauciflorum	Berries	63
,, ,, †	,,	20
,, ,, †	Buds, flowers	108
Picea (black) †	Needles	185
,, ,, †	Stalks	2
,, ,, †	Cone seeds	0

† Plants marked (†) were from Ladd Field; the others were from Rainbow Pass.

the middle of the summer. at the time when the Eskimos normally collect the plants for winter storage. It is interesting to note that the arctic willow, which constitutes an important part of the food supply for the musk-ox and the ptarmigan, is comparatively rich in vitamin C even during the winter. It may be added that the stomach content of a musk-ox killed in Pearyland, North-east Greenland, lat. 82° N., in August 1947 (mostly consisting of *Salix* sp.) contained 14 mg. vitamin C per 100 gm.

Three kinds of moss examined in Pearyland in August 1947 contained no vitamin C. Höygaard (1941) found that frozen crowberries contained no discernible vitamin C, and concluded that berries picked up later than November are of no importance as a source of vitamin C.

In a previous publication (Rodahl, 1944) it was pointed out that the vitamin C content in plants from North-east Greenland (lat. 74° N.) was generally higher than in the same plants from Angmagssalik, South-east Greenland (lat. 66° N.), examined by the same technique. This finding was verified in 1947 when the vitamin C content in plants from North-east Greenland (lat. 74° N.)

was compared with the vitamin C content in the same plants examined in Pearyland, North Greenland (lat. 82° N.), by the same technique, as is evident from Table IV.

TABLE IV.

VITAMIN C CONTENTS OF THE SAME SPECIES EXAMINED AT TWO DIFFERENT LOCATIONS IN GREENLAND.*

Species.	Mg. Ascorbic Acid per 100 gm.	
	Clavering Island, North-east Greenland, Lat. 74° N.	Pearyland, North Greenland, Lat. 82° N.
ALOPECURUS ALPINUS	40	170
CERASTIUM ALPINUM	42	85
ERIOPHORUM CALLITRIX	17	35
OXYRIA DIGYNA	95	119
PAPAVER RADICATUM	1	50
POA GLAUCA	12	50
SAXIFRAGA CERNUA	50	119
STELLARIA LONGIPES	59	135

* The plants were examined at the same time of the year, and the figures represent the average of 10 plants or more.

CONCLUSION.

On the basis of the reported findings, it may be concluded that vitamin C is well distributed through the more common arctic flora. When the natural resources of this vitamin are properly utilised, arctic plants may contribute significantly to the vitamin C intake in man in Arctic regions, while they are of comparatively little importance as a source of other vitamins and of calories. The previous findings by the author that the vitamin C content in arctic plants increases with the latitude have been confirmed.

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FEATURES ON PLANT CUTICLE.

AN AID TO THE ANALYSIS OF THE NATURAL DIET OF GRAZING ANIMALS, WITH ESPECIAL REFERENCE TO SCOTTISH HILL SHEEP.

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(With Plate X.)

(Read by title, 18th November 1954.)

INTRODUCTION.

A more complete knowledge, both qualitative and quantitative, of the self-selected diet of stock on free range would be an advantage in nutritional investigations and management methods. In 1952, the Scottish Hill Farm Research Committee suggested a study of "the cuticular remnants in sheep faeces in order to examine the possibilities of utilising faecal examination as a means of specific recognition of the plant components of the diet". This paper outlines the results of such a study.

Sheep rumen samples were available, and many of the preliminary investigations were done with them; at the same time, however, there have been investigations into faecal samples. The methods of the investigation apply equally well to both sources of material.

Various quantitative methods which have in the past been used to determine the composition of the diet of various animals may be summarised as follows:

(1) Woodward (1936) and Johnstone-Wallace and Kennedy (1944) deduced the diet of cattle from grazed and ungrazed swards.

(2) Analyses have been made, as by Woodman, Evans and Eden (1937) based on the percentage of dry matter in the faecal excretions of sheep.

(3) Analyses obtained by visual observations of animals on free range, as carried out by Stapledon and Jones (1926) among others.

(4) Analyses prepared from an examination of rumen or stomach contents (Norris, 1943; Tribe, 1950 *a*), but these analyses have given results which are not in accordance with the diet actually fed to the animal. Much of the variation was due to the large proportion of material (48–65 per cent.), which was too fragmentary to be identifiable. Tribe (1950 *a*) considers that an analysis of this

fragmentary material would be too time-consuming to be practicable under normal conditions.

The qualitative diet of hill sheep has previously been studied by Wallace (1884), Linton (1918) and Fenton (1937) among many others. Most workers used visual methods, either observation of the grazing animals, or by noting the species which showed signs of grazing.

Tribe (1950 *b*) reviews in greater detail the position regarding knowledge of the diet and behaviour of the grazing animal.

It was in an attempt to enable a more accurate qualitative analysis of hill sheep diet to be made that the work here described was carried out. A method is outlined whereby the fragmentary pieces in stomach contents referred to above (Tribe, *loc. cit.*) can be identified in a qualitative analysis. The basis of the work lies in the fact that much of the fragmentary material in rumen, stomach and faecal samples consists of plant cuticle which reflects by its structure and features the arrangement of the previously underlying epidermis.

In connection with diet analyses, published literature on the subject of these cuticle features is very sparse, more attention having been paid to the complete epidermis. Parkinson and Fielding (1930) compiled some epidermal characters of the constituents of commercial cattle food, mainly as a safeguard against adulteration. In this case the features were to be seen on the surface of the fragments, which were mostly completely opaque.

In the field of paleobotany, however, cuticle features have long been recognised as identification characters; *e.g.* Borneman (1856) and Nathorst (1907, 1908) found cuticle features useful in their paleobotanical investigations. Harris (1945) made use of these features in the identification and classification of Jurassic plants. In fossil material all cuticular structures are preserved; for example, external cuticle and internal cuticle as found on seeds and on spores.

Prat (1931) writes "almost all the workers who have studied the anatomy or the systematics of the Gramineae have remarked on the characters of the epidermal cells, which attain a higher degree of specialisation in that family than in any other". This specialisation is indeed very marked in the Gramineae, and in the different species studied there have been found specific differences in the epidermal arrangements. In the case of the Cyperaceae and some of the smaller herbaceous Dicotyledons the differences are not so marked, but are none the less distinguishable between species.

The methods outlined here show the way to a qualitative analysis of the diet of any animal, by means of rumen or stomach samples, or preferably, by the analysis of the faecal droppings.

METHODS.

A series of prepared slides of the cuticles of some forty upland hill plants has been built up, showing the markings or features of the cuticle peculiar to each species. The species consist of those which were suspected of being grazed by hill sheep in Scotland, and were collected from plants growing in the field. The collecting areas were at Ballochraggan (Perthshire), Drumclog Moor (Dunbartonshire) and Fenwick Moor (Renfrewshire and Ayrshire), all areas carrying a flora typical of hill sheep grazing land. It was found that cuticles of the same species from different areas showed the same pattern.

Samples of the cuticle from both the adaxial and the abaxial sides of the leaf were taken where possible, but in some cases it was found that the cuticle on either or both the sides was so thin that the technique used to remove it also destroyed it. This was especially so in the case of *Anthoxanthum odoratum* (Sweet Vernal Grass) and in some of the small herbaceous Dicotyledons, e.g. *Lotus corniculatus* (Birdsfoot Trefoil).

Since the growth in length of the grass leaf takes place mainly near the base of the leaf, it was found that no appreciable difference in cell length appeared as the samples were taken progressively nearer the tip of the leaf. Where the cells were still elongating more or less rapidly, *i.e.* at the base of the leaf, the cuticle was so thin that it would be disrupted or destroyed in the process of digestion. No trace of this thin basal cuticle has been found in the rumen or faecal samples investigated. In any case, it is rare that grazing animals bite so low as to take in as much of this tissue as to make it important in this system of identification. Thus, samples from the last few centimetres of the leaf were as diagnostic as those taken from lower down.

The leaves collected were cut into 2 cm. lengths, and a very thin strip taken off each edge to facilitate separation of the adaxial and abaxial sides. They were then macerated in 50 per cent. nitric acid in a water bath. The use of a water bath was found to be essential in order to reduce to a minimum the convection currents set up in the acid, as it was found that these currents were capable of breaking the cuticle into fragments too small to be of any value. Apart from this, a greater degree of control over the extent and rate of maceration was possible with the use of a water bath.

The maceration liquid, complete with cuticle and the internal tissues of the leaf, was then transferred to a petri dish, and the acid removed by gentle washing. The cuticles were then separated, if necessary, with a needle.

On examination of the cuticle at this stage it was invariably found that some of the epidermal tissue was still attached, and also a few fibres or vascular tissue. Although in many cases the presence of epidermal tissue was not detrimental, it was sometimes found that these cells stained so strongly that the markings on the cuticle were obscured. The fibres and the vascular tissue always stained strongly, and it was necessary to remove them.

A second maceration for this purpose had the effect of completely disintegrating the cuticle, and the only suitable method was found to be that of brushing the cuticle with a fine camel-hair brush, this being carried out under a binocular microscope. By this method all the fibre and vascular tissue, and most of the epidermal tissue were removed from the cuticle.

The cuticle pieces were then transferred through an ethyl alcohol series and taken up to the stain (Acid Fuchsin in an equal mixture of 95 per cent. ethyl and butyl alcohols). The cuticles were sufficiently stained in $\frac{1}{2}$–1 hour. They were then washed in 95 per cent. butyl alcohol and mounted in Euparal.

Photomicrographs were taken of these prepared slides. From the prints, and also by means of a camera obscura, data were obtained regarding the length, breadth and outline of the epidermal cells, the dimensions and features of the stomata and other structures present in the epidermis.

Plate X shows examples of adaxial and abaxial surfaces. Both are equally useful for identification purposes. In many cases only one surface could be recovered after maceration, and in the rumen and faecal samples the same situation is found. The other surface presumably can withstand neither the maceration nor the digestive processes. Since one surface alone is sufficient to indicate the presence of any plant, the loss of the other is no disadvantage.

The rumen and faecal samples were originally of too great a bulk for easy storage. About 100 gm. is ample for a qualitative analysis, and representative samples were taken from each main sample to give this amount. The small samples were stored in formalin-acetic-alcohol giving a final volume of 250 c.c.

The analyses were done under low power. The 250 c.c. samples were well mixed, 50 c.c. were removed by pipette to a petri dish, and some water was added. One hundred spot identifications were then made. Where the cuticle had much epidermal or other material still adhering, no identification could be made.

OBSERVATIONS AND DISCUSSION.

The grasses and herbage eaten by sheep and other ruminants pass into the rumen in a state not far removed from the natural growing condition, since they are passed directly into the rumen after being grazed. Here they undergo a softening effect, due to the presence and action of the rumen bacteria and secretions. In samples taken from the rumen, many of the plant fragments are large enough to be identified visually, but, both in rumen samples and in those taken from later stages, *e.g.* stomach or faeces, there is a great deal of plant material which is broken down into very small fragments.

Table I.

Sheep Rumen Sample Analyses.

Species.	Date Sampled.												
	11.1.51.	22.2.51.	24.3.50.	19.4.51.	4.5.50.	29.6.50.	13.7.50.	10.8.50.	7.9.50.	5.10.50.	7.11.50.	14.12.50.	Average Percentage.
Calluna vulgaris L.	29	28	23	22	31	34	22	30	33	36	22	42	29·25
Festuca rubra L.	15	22	28	12	15	18	25	19	22	12	17	14	19·10
Eriophorum vaginatum L.	8	11	15	11	15	17	12	7	16	21	13	4	12·50
Molinia caerulea L.	1	3	9	9	3	12	13	11	6	5	10	7	7·50
Aira flexuosa L.	14	6	4	6	3	3	2	3	10	5	4	14	6·20
Polytrichum spp.	12	11	4	20	6	0	2	0	2	1	9	2	5·75
Erica tetralix L.	11	5	3	8	4	2	7	4	1	4	6	4	5·00
Juncus effusus L.	1	2	0	1	7	2	1	0	0	3	7	2	2·20
Holcus lanatus L.	0	0	6	3	3	0	1	0	0	0	6	1	1·70
Luzula campestris L.	0	0	0	1	0	0	2	2	0	0	0	0	0·50
Potentilla tormentilla Neck	2	0	0	0	0	0	0	0	2	0	0	1	0·50
Sphagnum spp.	1	0	1	0	2	0	0	0	0	0	0	1	0·50
Carex flacca Schreb	1	0	1	0	1	0	0	0	1	0	0	0	0·30
Galium saxatile L.	0	0	0	0	0	0	1	2	0	0	0	0	0·25
Juncus squarrosus L.	0	1	1	0	0	1	0	0	0	0	0	0	0·25
Vaccinium myrtilis L.	0	0	0	0	0	0	0	0	0	0	0	0	0·00
Unknown fragments	5	11	5	7	10	11	12	22	7	13	6	8	9·70

The smaller fragments of plant material in these samples consist of fibres, hairs and connective tissue, in a partly digested, gelatinous state. Mixed with these fragments are pieces of cuticle. The cuticle portions carry features on them as described above and can be identified as belonging to specific plants; the other plant fragments are too indistinct, non-specific or in too fine a state to be of any great value in an analysis.

The pieces of cuticle in these samples vary in length from 0·1 mm. to between 1 and 2 mm. Fragments smaller than 0·1 mm. do not normally carry enough features to make identification conclusive, while those fragments of 1 mm. and larger often have epidermal cells and fibres still attached, making them almost opaque. The action of the stomach juices appears to darken the cells attached to the cuticle.

TABLE II.

FAECAL SAMPLE ANALYSES.

Species.	Sample.							
	1	2	3	4	5	6	Avge. %	7
FESTUCA RUBRA L.	34	31	36	34	40	36	35·17	35
ERIOPHORUM VAGINATUM L.	10	15	9	14	13	9	11·83	10
POLYTRICHUM spp.	13	6	18	12	6	13	11·33	8
MOLINIA CAERULEA L.	8	12	10	10	8	15	10·50	11
AIRA FLEXUOSA L.	6	9	5	8	6	4	6·33	4
CALLUNA VULGARIS L.	8	8	2	5	8	4	5·83	1
JUNCUS EFFUSUS L.	9	7	3	0	0	3	3·73	14
HOLCUS LANATUS L.	4	0	2	6	3	3	3·00	2
ERICA TETRALIX L.	0	1	2	3	1	1	1·33	3
GALIUM SEXATILE L.	2	0	4	0	1	1	1·33	0
CAREX FLACCA Schreb	0	0	0	0	3	2	0·53	2
SPHAGNUM spp.	0	0	2	1	0	0	0·50	1
LUZULA CAMPESTRIS L.	0	0	1	1	0	0	0·33	2
VACCINIUM MYRTILIS L.	0	0	1	0	0	0	0·17	0
JUNCUS SQUARROSUS L.	0	0	0	0	0	0	0·00	0
POTENTILLA TORMENTILLA Neck	0	0	0	0	0	0	0·00	1
Unknown fragments	6	11	5	6	11	9	8·00	6

All faecal samples were collected on 23.7.54.

Samples 1–6 were from Blackface ewes, and Sample 7 from a Highland cow.

In faecal samples the attached epidermal material is much less noticeable than in rumen samples, and, in a great many cases, is completely digested, leaving the cuticle quite transparent.

It will be noted from Tables I and II that despite the wide range of cuticles prepared from known plants there were cases where an unknown cuticle pattern was encountered. Also the reduced range in cuticles recognised, *i.e.* 16 recognised in samples (40 known from prepared slides), suggests that many are completely digested, or reduced to such small fragments that identification is impossible.

There are notable deficiencies in the list of species identified from the samples, *e.g. Aira caespitosa* L., *Nardus stricta* L., *Anthoxanthum odoratum* L. and *Trichophorum caespitosum* L. These plants are undoubtedly eaten by sheep, and are present on the areas where the samples were obtained. The lack of cuticles from such plants may be due to the action of the digestive juices, as mentioned above. *Anthoxanthum odoratum* L. has already been noted as having an easily destroyed cuticle.

It will be seen in Table I (rumen samples) that *Calluna vulgaris* L. formed some 30 per cent. of the total count, whereas in Table II (faecal samples) this figure falls to 6 per cent. The high incidence in the rumen samples is possibly due to the fact that fragments of *C. vulgaris* are easily recognisable, even where the complete epidermis is adhering to the cuticle, whereas most of the fragments of other plants are completely masked, in rumen samples, if epidermis is present. In the faecal samples the cuticles are all much more free of epidermal material, and are equally easily recognised, thus giving a more accurate estimate of the diet.

The high incidence of *Polytrichum* spp. is also partly due to this factor. Also, the fragments of this genus are no doubt pulled with other plants, and it is doubtful if they are eaten deliberately.

This system of diet analysis is of little use in quantitative investigations, but it is of extreme value in qualitative investigations, especially where there is a somewhat restricted range of plants available to the animal.

The use of faecal droppings as the source of material for investigation obviously means no interference with the normal grazing habits of the animal, since no rumen fistulas or other internal methods are required to provide a sample.

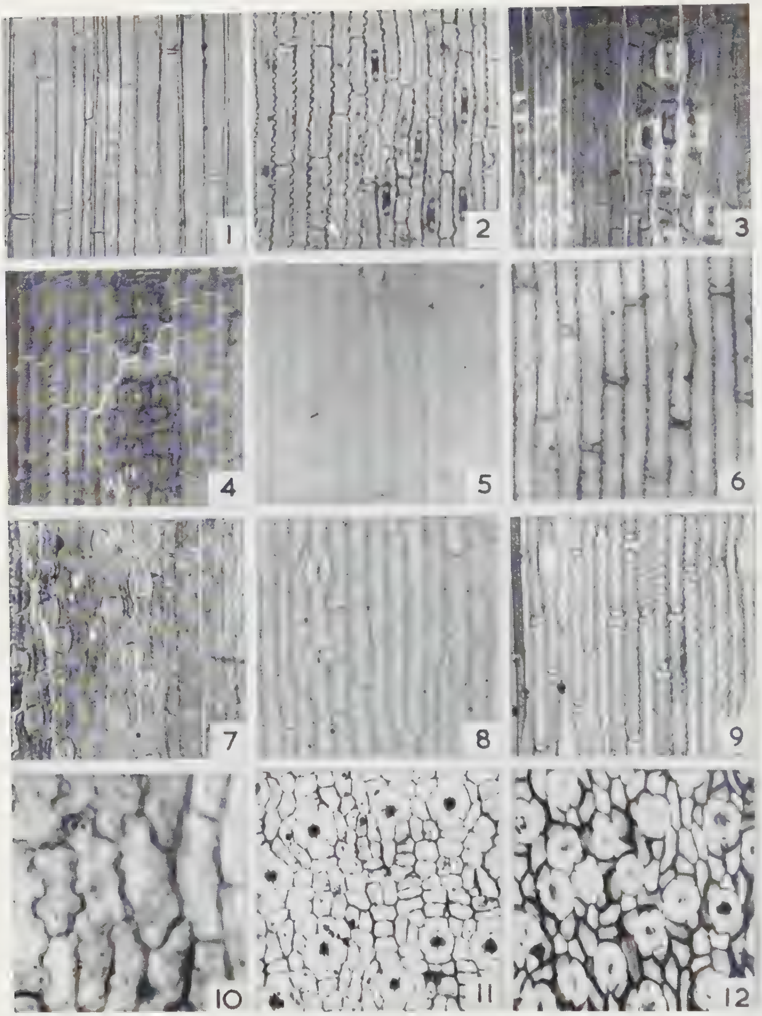
APPENDIX.

In Plate X are shown some examples of the various features found on the cuticle of different leaf surfaces and young stems. The photomicrographs are arranged so that their vertical side is parallel to the leaf veins or main vein, or to the length of the stem.

Two species of *Eriophorum* and *Festuca* are shown to illustrate the differences found between species.

AIRA FLEXUOSA L. (WAVY HAIR GRASS) (1)

Epidermal cells of 220 μ average length; the range in length is from 150 to 400 μ, with most cells between 200–325 μ. The average



1. Aira flexuosa L., adaxial surface of leaf.
2. Carex caryophyllea Latour, abaxial surface of leaf.
3. Eriophorum angustifolium Honck, abaxial surface of leaf.
4. Eriophorum vaginatum L., abaxial surface of leaf.
5. Festuca pratensis Huds., adaxial surface of leaf.
6. Festuca rubra L., adaxial surface of leaf.
7. Juncus effusus L., cylindrical leaf.
8. Luzula campestris L., adaxial surface of leaf.
9. Molinia caerulea L., abaxial surface of leaf.
10. Galium saxatile L., adaxial surface of leaf.
11. Ulex europaeus L., stem.
12. Vaccinium myrtillus L., stem.

(All × 62·5.)

David J. Martin.

width is 18·7 μ. There are faint corrugations present on the cell walls, and these occur at the rate of 19 corrugations on 100 μ of cell wall.

Hair cells occur, mainly in single vertical rows, with 6–8 rows of epidermal cells between, and at least one epidermal cell between in a vertical direction. The hair cells are 30–40 μ square and the hairs are 50–60 μ long.

No stomata were found on this side of the leaf.

CAREX CARYOPHYLLEA Latour (EARLY SEDGE) (2)

Epidermal cells of 130 μ average length, varying from 80 to 200 μ. The average width is 17 μ. The cells are strongly corrugated, these corrugations occurring at the rate of 14 on 100 μ of cell wall. The stomata, of 60–70 μ length and 30–40 μ breadth, appear at first glance to occur within the epidermal cells. In fact, the width of the stomata, with their complementary cells, corresponds exactly to the width of the epidermal cells which are at either end of the stomata. (In most other species the stomata are wider than the epidermal cells.) The stomata are in rows, two or three cells wide, each group separated horizontally by 5–8 rows of epidermal cells with no stomata. Vertically the stomata are separated by 1–5 epidermal cells.

Glandular cells occur, in long vertical rows one cell wide. These cells are 30–40 μ long, and have from 1 to 4 glandular protuberances.

ERIOPHORUM ANGUSTIFOLIUM Honck (TUFTED COTTON GRASS) (3)

Epidermal cells of 51 μ average length, varying from 36 to 70 μ. The average width is 17 μ. The cells are faintly corrugated at the rate of 17·5 corrugations on 100 μ of cell wall. The stomata, 40 by 36 μ, are found in broken vertical rows, not usually more than two stomata being adjacent horizontally. Between the rows of stomata are 5–8 rows of epidermal cells with no stomata. In these 5–8 rows occur glandular cells, usually one cell wide. Each cell contains 1–4 protuberances.

ERIOPHORUM VAGINATUM L. (HARE'S TAIL COTTON GRASS) (4)

Epidermal cells of 51 μ average length, mainly between 40–56 μ. The average width is 16 μ. The cell walls are strongly corrugated at the rate of 20 corrugations on 100 μ of cell wall. The stomata are 26–30 μ long and 20 μ wide. They occur in rows, not so widely spaced as in *E. angustifolium*, with only 4–6 rows of epidermal cells between. At some points, however, there is a very much greater horizontal separation, there being 10–18 rows of epidermal cells between the rows of stomatal cells.

Glandular cells similar to those of *E. angustifolium* are found, but the lines of these are not so complete vertically as in the other species, nor are there so many places where there are two glandular cells side by side.

FESTUCA PRATENSIS Huds. (MEADOW FESCUE) (5)

Epidermal cells of 750 μ average length, varying from 600 to 1200 μ. The average width is 25 μ. and little deviation from this is found. The sides of the cells are not corrugated. The ends of the cells are vertical, and show only a single line at their junction.

FESTUCA RUBRA L. (RED FESCUE) (6)

The epidermal cells are of 244 μ average length, ranging from 180 to 300 μ. The average width is 46·6 μ and little deviation is found from this. The cell walls are corrugated at the rate of 12·3 corrugations on 100 μ of cell wall. The end walls of the cells are at an angle to the normal at the surface, and there is an apparent double line at the end of each cell.

No stomata were found on this surface.

JUNCUS EFFUSUS L. (SOFT RUSH) (7)

Epidermal cells of 42·5 μ average length, ranging from 30 to 50 μ. The average width is 13·6 μ; this figure is exceeded slightly by the cells between the stomatal rows, whereas those cells within the stomatal rows do not quite attain this average. The cells are strongly corrugated at the rate of 19·2 corrugations on 100 μ of cell wall.

The stomata are 24 μ by 16 μ, and are found in rows of up to 6 cells wide. Between the rows of stomata there are 4–6 rows of epidermal cells, while vertically the stomata are separated by 2–5 epidermal cells.

LUZULA CAMPESTRIS L. (FIELD WOODRUSH) (8)

Epidermal cells of 127 μ average length and of 21 μ average width. The walls are strongly corrugated at the rate of 12 corrugations on 100 μ of cell wall. The stomata are in rows one cell wide, and are 40 by 30 μ. The rows are separated horizontally by 14–18 rows of epidermal cells, and vertically the stomata are separated by 1–3 epidermal cells.

The end walls of the epidermal cells are U-shaped with no overlapping.

Molinia caerulea L. (Purple Moor Grass) (9)

Epidermal cells of 131 μ average length, varying from 80 to 160 μ, and of 15 μ average width. The walls are strongly corrugated at the rate of 15 corrugations on 100 μ of cell wall. The stomata are in rows, usually not more than one cell wide, the rows separated by 10–14 rows of epidermal cells. The stomata are 32 μ by 18 μ, and are separated vertically by at least one epidermal cell.

The remaining three examples of cuticle features (10–12) are of Dicotyledons. As will be seen, the cells are much less regular than in the Monocotyledons, and identification of these patterns is more by familiarity than by the use of average cell sizes. Over veins the cells tend to be more regular and rectangular. The stomata are irregularly placed, but the pore opening tends to lie parallel to the nearest vein.

SUMMARY.

Cuticle fragments can be found in rumen, stomach and faecal samples, and the features shown by these fragments can be compared with those of cuticles from known plants.

Since the features, so far as have been studied, are specific, the fragments can be used to identify the plants grazed, and a qualitative analysis of the animal diet made in this way.

The advantage of the system lies in the fact that faecal droppings can be the source of the material to be identified; hence, neither fistulas nor slaughter need be resorted to in order to obtain material.

The analyses of 19 samples using this method are included.

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POLLEN GRAIN SIZE IN NASTURTIUM AND CAKILE.

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INTRODUCTION.

This study was undertaken to test with what reliability the size of pollen grains can be used to differentiate between the species of a polyploid pair. Two such pairs of species were studied: the water-cresses because considerable material of them exists in herbaria, and the sea-rockets in the hope that, at the same time, the occurrence in Britain of the North American species *Cakile edentula* (Bigel.) Hook. might be confirmed.

METHOD.

For speed and simplicity the method of Johnston (1952, p. 308) was employed, except that lactophenol was used instead of lactic acid. Pollen from either living or herbarium specimens was mounted in a small drop of lactophenol and covered with a thin cover-slip. The pollen in both genera is ellipsoidal, but on expansion in the lactophenol some grains became more or less spherical and, in two specimens of *Cakile*, slightly broader than long. It soon became obvious that there was considerable variation both in length and in breadth of grains from any one specimen, and that a sample would need to be taken from each, and the average length and breadth calculated. It was thought that ten grains should prove a sufficient sample, but to confirm this two hundred were measured from one specimen of *C. maritima* Scop. The ranges and averages of the first 10, 50, 100 and 200 grains measured are shown in Table I and

TABLE I.

RANGES AND AVERAGES OF LENGTH AND BREADTH IN TEST MEASUREMENT OF 200 POLLEN GRAINS FROM CAKILE MARITIMA.

	Length in Microns.	Breadth in Microns.
First 10 grains measured .	(35–) 37·2 (–39)	(30–) 31·5 (–33)
First 50 grains measured .	(35–) 37·52 (–41)	(30–) 31·74 (–34)
First 100 grains measured .	(35–) 37·43 (–41)	(30–) 31·69 (–34)
First 200 grains measured .	(34–) 37·43 (–41)	(29–) 31·58 (–35)

TRANS. BOT. SOC. EDIN., VOL. XXXVI. PT. IV., 1955.

the ranges depicted diagrammatically in fig. 1. It will be seen that very little additional accuracy is gained by taking a larger sample than ten, and because numerous specimens had to be sampled and the measurement of pollen grains is a relatively slow business, especially when both length and breadth have to be measured, a standard sample of ten grains was adopted.

Two further tests were carried out: one to see whether there was any expansion or shrinkage of the grains after they were mounted, and the other to see if there was any difference between grains from living and herbarium material.

Pollen from a relatively old herbarium specimen of *C. maritima* was mounted and ten grains were measured immediately. These same ten grains were then remeasured after half an hour, one hour, two hours, one day, two days, one week and three weeks. No change in size was noted during the first two days, and after a week there was a shrinkage in length of just under one micron, whilst after three weeks the shrinkage was of the order of 3–4 microns; a shrinkage of approximately 10 per cent. In breadth the shrinkage after three weeks was approximately one micron, with the result that the grains tended to become more or less spherical. Any measurements made after the first two or three days might therefore be unreliable; as all the measurements made during this investigation were made during the first twenty-four hours after mounting, any error due to shrinkage is negligible.

Pollen grains were taken from a living specimen of *C. maritima*, mounted, and ten of them measured immediately. The same grains were measured after periods of half an hour, one hour, two hours, one day and one week, and, as with the measurements cited in the paragraph above, no change was noticed in the first day and a very small change of less than one micron after a week. This same specimen was placed in a flower press, and when fully dry, pollen was taken from it, mounted and measured. A shrinkage of 3–4 microns took place both in length and breadth, but the mean dimensions still remained within the range of variation exhibited by the species (see Table III and fig. 3). However, this statement is based on a single observation, and from measurements of pollen from living specimens of *Nasturtium* it is suspected that this shrinkage is not a constant phenomenon; nevertheless it is suggested that it is desirable to work with material which is always of the same type.

In all cases only grains observed in full side view were measured, and apart from this no other selection was made. That the grains

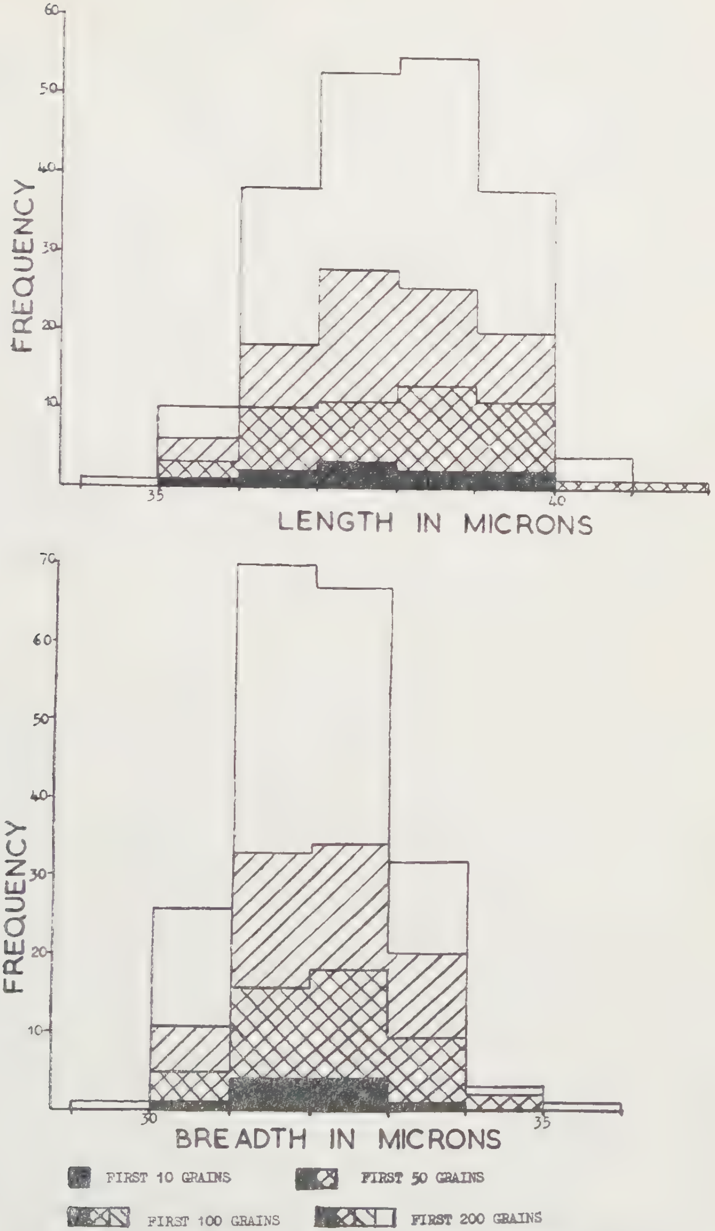

FIG. 1.—Frequency histograms of the dimensions in the test measurement of 200 pollen grains from a single specimen of *Cakile maritima*.

Upper histogram: Length of pollen grains.
Lower histogram: Breadth of pollen grains.

were in full side view was ascertained by observing the position of the colpe and the thickness of the exine. Furthermore, the measurements quoted in this paper were obtained with the use of the same microscope and optical system throughout, using a $\frac{2}{3}$ objective, a ×10 eyepiece, and the draw-tube adjusted until each division of the micrometer scale represented 3 microns; the pollen grains were then measured to the nearest estimated third of a division, *i.e.* to the nearest micron. Other investigators may find that they disagree with these measurements by two or three microns, for microscopic measurements by individual workers vary considerably, even when every care and precaution for standardisation is taken. For example, Harter (1939) records that nine experienced workers, familiar with the technique of measuring spores, and all using the same microscope to measure one hundred spores from the same microscopic preparation, showed an extreme difference of 1·9 μ between the individual average lengths, a difference representing between 4 and 8 per cent. of the length of the spores. Greater differences can therefore be expected when different microscopes, etc. are used by different investigators.

NASTURTIUM.

Watercress exists as two species, the diploid *Nasturtium officinale* R. Br. sens. str. (*Rorippa Nasturtium-aquaticum* (L.) Hayek), ($2n=32$), and the tetraploid *N. microphyllum* Boenn. ex Rchb. (*Rorippa microphylla* (Boenn.) Hyl.), ($2n=64$) (Howard and Manton, 1946), with the sterile triploid hybrid between them, sometimes distinguished by the name *Rorippa* × *sterilis* Airy Shaw (Shaw, 1951).

Specimens from nearly every part of the recorded world-range were investigated: 131 dried specimens from the Herbarium of the Royal Botanic Garden, Edinburgh, 22 from the Herbarium of the Royal Botanic Gardens, Kew, and 11 living specimens collected in the field.

Of these 164 specimens, 28 were found to produce only a very small proportion of normally developed grains, very variable in size and with the greater proportion apparently abortive. Furthermore, 17 of these 28 specimens were mature enough to show that the fruit also was abortive, and this confirmed their identification as the sterile hybrid. Brief reference is also given to the production of abortive pollen by Manton (1935, p. 141, and pl. ii, fig. 25) and by Howard and Lyon (1952, p. 242).

For the remaining 136 fertile specimens, the averages of each measurement of 10 grains are listed in size groups in Table II and plotted in the form of histograms in fig. 2. It will be seen that two groupings (marked "O" and "M" in the figures) were obtained for both length and breadth, representing the range of pollen grain

TABLE II.

AVERAGE DIMENSIONS OF EACH MEASUREMENT OF 10 POLLEN GRAINS IN NASTURTIUM LISTED BY FREQUENCIES.

LENGTH.				BREADTH.			
Length in Microns.	Frequency.	Length in Microns.	Frequency.	Breadth in Microns.	Frequency.	Breadth in Microns.	Frequency.
22·0	1	26·3	3	20·3	1	23·9	7
22·7	1	26·4	1	20·4	1	24·0	4
22·8	1	26·5	2	20·5	1	24·1	8
23·2	1	26·6	1	20·7	1	24·2	4
23·3	2	26·8	2	20·8	2	24·3	2
23·4	2	26·9	2	20·9	5	24·4	3
23·5	1	27·1	1	21·0	6	24·5	1
23·6	1	27·2	1	21·1	12	24·6	1
23·8	1	27·3	3	21·2	4	24·9	1
23·9	3	27·4	1	21·3	2	25·2	1
24·0	4	27·5	1	21·4	8		
24·1	5	27·6	1	21·5	6		
24·2	5	27·7	1	21·6	7		
24·3	7	27·8	3	21·7	2		
24·4	4	27·9	3	21·8	3		
24·5	3	28·0	1	21·9	9		
24·6	4	28·2	1	22·0	3		
24·7	2	28·3	3	22·1	3		
24·8	3	28·4	1	22·2	3		
24·9	2	28·6	2	22·3	2		
25·0	4	28·9	2	22·4	1		
25·1	2	29·1	2	22·5	4		
25·2	3	29·2	2	22·9	1		
25·3	2	29·3	2	23·1	2		
25·4	3	29·4	2	23·2	1		
25·5	5	29·5	2	23·3	2		
25·6	6	29·7	1	23·4	1		
25·8	1	29·8	2	23·5	2		
25·9	1	30·1	1	23·6	3		
26·0	1	30·2	2	23·7	3		
26·2	2	30·3	1	23·8	3		

sizes in the diploid and tetraploid species, the diploid having the smaller grains. Very brief references to pollen grain size are given by Manton (1935, pl. ii, figs. 24 and 26) and by Howard and Lyon (1952, p. 240).

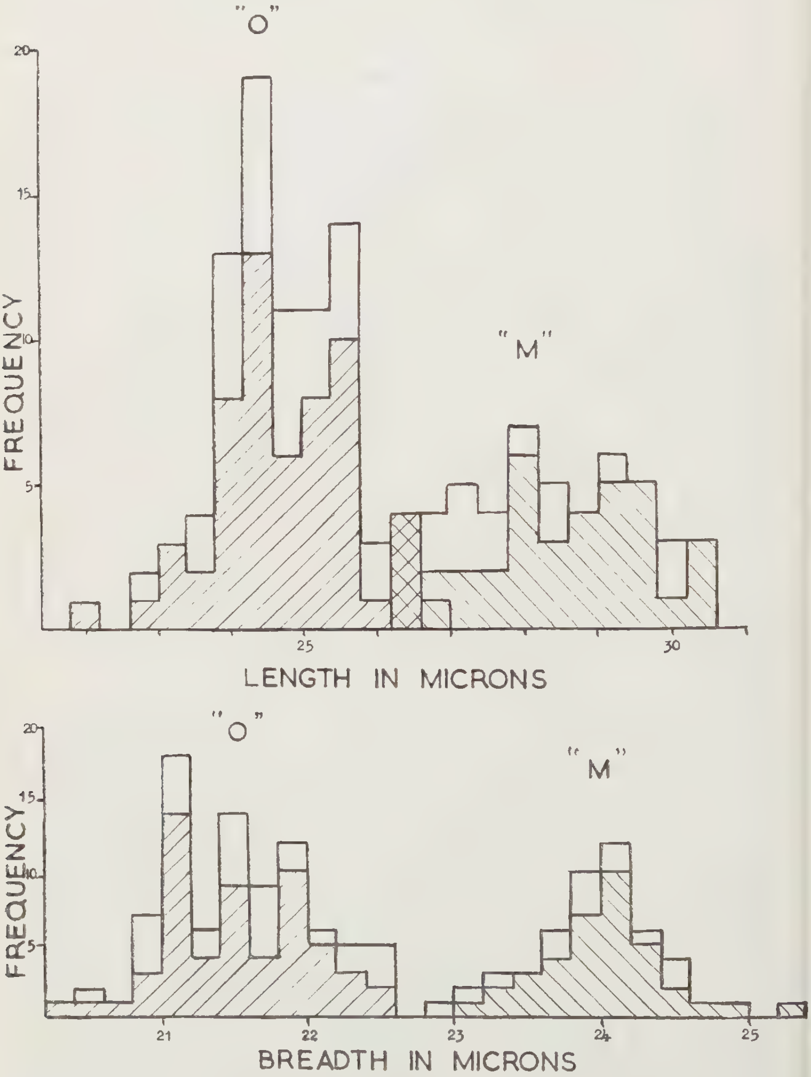

Fig. 2.—Frequency histograms of pollen grain dimensions in *Nasturtium*. The shaded portion represents those specimens identifiable by fruit characters.

Upper histogram: Length of pollen grains.
Lower histogram: Breadth of pollen grains.

The easiest and most certain way of distinguishing the species is by characters of the fruit and seed, but it is apparent that pollen grain size can also be used. Of these 136 specimens, 94, or approximately 69 per cent. were also identifiable by fruit and seed characters, and in no single case was there disagreement between identification from fruit morphology and pollen grain size (the relative position of these 94 specimens is shown in the figures by shading). The ranges for length overlap very slightly, but the identity of any individual specimen falling into this zone of overlap could always be determined from the breadth of its grains, where the ranges are quite distinct and discrete. The averages and total range of the dimensions of the 136 samples of 10 grains was found, for *N. officinale*, to be (22·0–) 24·7 (–26·6) $\mu \times$ (20·3–) 21·5 (–22·5) μ, and for *N. microphyllum*, (26·3–) 28·3 (–30·3) $\mu \times$ (22·9–) 23·9 (–25·2) μ, whilst the total range for the extreme dimensions of individual grains, 21–28 $\mu \times$ 18–24 μ and 25–32 $\mu \times$ 21–27 μ respectively.

It will be seen that the differences in mean grain lengths and breadths between individual specimens are very much smaller than the variations found in the measurements of different workers as cited above; the dimensional ranges must therefore be established for each investigator if pollen grain size is to be used with confidence as a means of identification. With this proviso this method may safely be employed, and as the measurement of 10 grains is a simpler matter than the calculation of the stomatal index or the counting of the chromosomes, it will no doubt prove of considerable value when early identification is needed in such work, as for instance the extensive trials which are taking place for resistance to Crook Root disease in watercress (Tomlinson, personal communication).

Distributional Records in Britain.

When studying the distribution of the two species from herbarium material, chromosome counts are impossible, and owing to the relatively thin soft nature of the leaf the determination of the stomatal index of any particular dried specimen is far from easy. However, as almost all herbarium specimens are at least at the flowering stage, pollen can be obtained, and one of the incidental results of this investigation has been the identification of herbarium material previously unidentifiable. In the case of some British specimens, identification was made for vice-counties where the parental species or hybrid had not been previously recorded. The vice-comital distribution of the two species and the hybrid, as far as it was known at that time, is given by Howard and Lyon (1950, 1951); however, it is now possible to add a few additional records from the Herbarium of the Royal Botanic Garden, Edinburgh, both for the reason stated above, and because further material, not seen by Howard and Lyon, has been examined by the author. These records, listed by vice-counties, are as follows:

N. OFFICINALE R. Br.

98. Argyll. Loch Baile a'Ghobhainn, Lismore, 1904, G. T. West.
100. Clyde Isles. Shisken, Arran, 1883, A. Somerville.
108. W. Sutherland. Melvich, 1897, s.n.; and Bettyhill, 1954, J. Anthony.

N. MICROPHYLLUM Boenn. ex Rchb.

66. Durham. Darlington, 1803, W. Backhouse.

N. MICROPHYLLUM × OFFICINALE.

20. Herts. Walsworth Common, 1871, T. B. Blow.
72. Dumfries. Brownhall, 1839, J. Cruickshank.
93. N. Aberdeen. Old Meldrum, 1879, G. Watt 2702.
111. Orkney. Stromness, Mainland, 1920, H. H. Johnston 876.

In addition to these new records the following are records earlier than those given by Howard and Lyon:

N. MICROPHYLLUM.

90. Forfar. Near Forfar, n.d., G. Don.

N. MICROPHYLLUM × OFFICINALE.

68. Cheviot. Belford, 1883, ex herb. Terras.
90. Forfar. Round Loch of Lundie, 1916, D. R. Robertson.
110. O. Hebrides. Barra, North Bay, 1936, Edinburgh University Biological Society 1936 Expedition.

Other Distributional Records.

The various countries from which *N. microphyllum* has been recorded are given by Shaw (1948) and Hylander (1950) but, as a result of this investigation, the following additions can be made. (The letters "E" and "K" show whether the specimen is in the Herbarium of the Royal Botanic Garden, Edinburgh, or the Royal Botanic Gardens, Kew, respectively.)

Holland. Dedemsvaurt, 14th July 1886, James Watson (E).
Switzerland. Genève, s.d., N. C. Seringe (E).
Belgian Congo. Indata, 27th February 1927, D. H. Linder 2202 (K).
Sudan. N. Jebel Marra, Darfur, 7000 feet, 7th May 1932, M. Steele 30 (K).
U.S.A. District of Columbia, Washington and district, springs and brooks, 9th May–15th June, E. S. Steel (E).
  Idaho, Picabo, Blaire Co., wet bank along creek, 4900 feet. 3rd July 1916, J. F. Macbride and E. B. Payson 3009 (E).
  Michigan, near Port Huron, 9th July 1895, C. K. Dodge (E).

In connection with this record from the Sudan, it is interesting to note that Andrews (1950) records *N. officinale* R. Br. from "Jebel Marra, Darfur, 6500 feet". It is apparent that the plant from Jebel Marra is actually *N. microphyllum*, although Andrews is probably referring to *N. officinale* R. Br. in the broad sense.

From California Shaw (1948), while stating that it is a doubtful specimen, cites one gathered by E. B. Copeland in 1929 (Copeland 368). He was right to express doubt, for examination of pollen taken from a duplicate in the Edinburgh Herbarium shows that it cannot be *N. microphyllum*. The average dimensions of the pollen, from the measurement of 10 grains, are $39{\cdot}9 \times 36{\cdot}3\ \mu$, as compared with a maximum for *N. microphyllum* of $32 \times 27\ \mu$. In addition the exine is thicker and the reticulations smaller. The specimen is rather inadequate, but it is probably a species of *Cardamine* L.

Records of the hybrid *N. microphyllum* × *officinale* from France and Germany are given by Shaw (1951) and from Sweden by Hylander (1950), whilst its occurrence in Austria is shown in the map given by Manton (1935, p. 137). In addition records can now be added from:

Hungary. "Ad rivulum prope pag. Felsö-Göd, prope Danubium", 27th August 1916, A de Degen (E).
Japan. Without locality, L. Savatier 1866–74 (K).
  Hakodate, Prov. Oshima, Yezo, 10th July 1890, K. Miyabe (K).
  Tokyo, introduced, July 1908, ex herb Yokohama Nursery Co. Ltd. (E).
  Without locality, April 1910, N. Mochizuki (E).
  Tokyo, 26th May 1910, M. Sakurai (E).

India.	Poona, without date, Mr. Woodrow (Herb. Watt, E).
Kenya.	Katamaju Forest, 7300 feet, February 1939, P. R. O. Bally 8653 (K).
	Kijabe, swamp on plateau, 7000 feet, July 1949, P. R. O. Bally 7386 (K).
U.S.A.	Idaho, Flint Creek, Owyhee County, swampy meadows, 4200 feet, 30th July 1910, J. F. Macbride 492 (E).
	Kentucky, without locality, 1853, C. W. Short (E).

The specimen from Poona, though somewhat inadequate, seems quite clearly to be a watercress, and its pollen is that characteristic of the hybrid.

The Japanese records too are particularly interesting, in that whilst *N. officinale* sens. str. has been identified from as near as Pekin (T. N. Liou 1321), *N. microphyllum* has not been recorded nearer than Turkestan and Afghanistan (Shaw, 1948). From conversation with Dr. H. Hara of Tokyo, I understand that watercress is almost certainly an introduction to Japan, and it seems that it is the hybrid which has been introduced. Whether either of the parental species is to be found there is not known, but the five specimens examined constitute all the material from Japan to be found in the Edinburgh and Kew Herbaria. Thunberg in his *Flora Japonica* of 1784, under the name *Sisymbrium Nasturtium*, gives watercress as very common, but this is probably due to an error in identification. However, there is no mention of the species in Juel (1918), so presumably no specimen exists in Thunberg's herbarium.

CAKILE.

The two species of *Cakile* that possess the widest distribution are *C. maritima* Scop. which occurs round the Atlantic coast of Europe, the Mediterranean and the Black Sea, and *C. edentula* (Bigel.) Hook. which occurs round both the Atlantic and Pacific coasts of temperate N. America, Iceland and the Azores, and has been claimed to occur in N. Scotland (Allen, 1952); both species occur as aliens in Australia. As with the watercress, the only certain way of distinguishing between the species is by the use of fruit characters; for although *C. edentula* never shows the deeply pinnatifid leaves of *C. maritima*, individuals of *C. maritima* often occur with leaves which are almost entire. The two species also form a polyploid pair: *C. maritima* ($2n=18$) and *C. edentula* ($2n=36$), (Löve and Löve, 1947).

Ninety-one specimens of *C. maritima* and *C. edentula* were sampled. and the averages of each measurement of 10 grains are listed by size groups in Table III and plotted in the form of histograms in fig. 3.

TABLE III.

AVERAGE DIMENSIONS OF EACH MEASUREMENT OF 10 POLLEN GRAINS IN CAKILE MARITIMA AND C. EDENTULA LISTED BY FREQUENCIES.

LENGTH.				BREADTH.			
Length in Microns.	Frequency.	Length in Microns.	Frequency.	Breadth in Microns.	Frequency.	Breadth in Microns.	Frequency.
29·5	1	35·1	1	27·0	1	32·6	1
30·2	1	35·2	2	28·4	1	32·7	3
30·9	1	35·3	2	29·2	1	32·8	3
31·5	1	35·4	2	29·4	1	32·9	5
31·7	1	35·6	3	29·5	3	33·0	1
31·8	1	35·7	1	29·7	3	33·1	1
32·1	2	35·8	3	29·9	1	33·2	3
32·4	2	35·9	2	30·1	1	33·5	1
32·6	1	36·1	1	30·2	1	33·7	1
32·7	1	36·2	6	30·3	2	33·8	1
33·0	1	36·3	1	30·4	3	34·2	2
33·1	1	36·5	1	30·5	3	34·8	1
33·2	3	36·7	1	30·6	3	34·9	2
33·3	1	36·8	1	30·8	1	35·4	1
33·4	1	36·9	3	30·9	1	35·5	1
33·5	1	37·1	1	31·2	4	36·2	1
33·6	4	37·3	1	31·4	1	36·6	2
33·7	1	38·1	1	31·5	3	37·0	1
33·8	1	38·2	1	31·7	6	37·1	1
33·9	4	38·4	1	31·8	2		
34·0	1	38·8	2	31·9	3		
34·2	1	39·1	1	32·0	1		
34·3	2	39·2	2	32·1	1		
34·4	7	39·3	1	32·2	4		
34·5	3	39·4	1	32·3	4		
34·7	1	40·0	1	32·4	2		
34·8	1	40·3	1	32·5	2		
35·0	1						

It will be seen that in this case only one grouping was obtained for both length and breadth. Furthermore, some specimens of both species were determinable by fruit characters and their averages occur in all parts of the range (indicated in the figures by crosses and dots), and it is therefore clear that identification of species by the use of pollen grain size is not possible in *Cakile*.* The averages and total range of the dimensions of the 91 samples of 10 grains was found to be (29·5–) 35·1 (–40·3) $\mu \times$ (27·0–) 32·1 (–37·1) μ, and the total range for the extreme dimensions of individual grains 28–42 $\mu \times$ 26–39 μ.

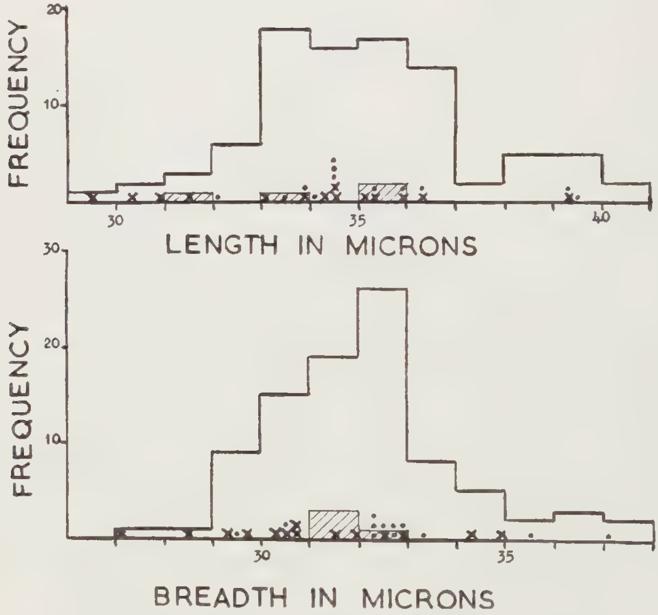

FIG. 3.—Frequency histograms of pollen grain dimensions in *Cakile maritima* and *C. edentula*; the position of individual specimens identifiable by fruit characters is indicated by crosses and dots respectively. The shaded portion represents the position of specimens of *C. lanceolata*.

Upper histogram: Length of pollen grains.
Lower histogram: Breadth of pollen grains.

As far as is known, the chromosome number in *C. edentula* has only been determined from Icelandic material (Löve and Löve, 1947). However, two specimens from Iceland were sampled in this investigation and their pollen grain size lies within the general range.

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* Two other species of *Cakile* exist: *C. arabica* Velen. & Bornm. and *C. lanceolata* (Willd.) O. E. Schulz. No specimen of *C. arabica* was seen, whilst the range of pollen grain size for the four specimens of *C. lanceolata* examined was also found to be coincident with that of *C. maritima* and *C. edentula* (see fig. 3). The total range and average of pollen grain size for the four specimens was (29–) 34·0 (–37) $\mu \times$ (28–) 31·6 (–34) μ.

In fact, specimens of both *C. maritima* and *C. edentula* from all parts of their geographical range were sampled, including two specimens from N. Scotland determined by A. Löve as *C. edentula*. Furthermore, it is interesting to note that both the species and a sterile hybrid plant are recorded by J. W. Heslop Harrison (1954) from Harris in the Outer Hebrides. In this hybrid the complete sterility recorded for both ovules and pollen is the condition that would be expected with diploid and tetraploid parents.

The fact that the two species of *Cakile* cannot be distinguished by the possession of pollen grains of different sizes was unexpected. In addition to *Nasturtium*, such differences have been recorded for polyploid pairs in a wide range of genera from numerous families; for example: *Pyrola* (Overbeck, 1934), *Dactylis* (Müntzing, 1937), *Tradescantia* (Sax and Sax, 1937), *Youngia* (Babcock and Stebbins, 1937). *Primula* (Bruun, 1938) *Datura*, *Cannabis*, *Cosmos*, *Cucurbita* and *Portulaca* (Blakeslee, 1941), *Empetrum* (Erdtman, 1943, p. 91), *Rumex* (Löve, 1944), *Valeriana* (Skalinska, 1947) and *Sanicula* (Bell, 1954). In fact Blakeslee (1941, p. 186), in connection with his extensive investigations, says, "so far we have found no exception to the rule that doubling chromosome number increases notably the size of the pollen grains".

At one time in this investigation *Cakile* was thought to be the first case where such a relation does not exist, but it was found that Earnshaw (1942, p. 159) makes a brief reference to the fact that in *Plantago* "preliminary studies have failed to show any difference in the mean sizes of pollen grains derived from diploid and tetraploid plants", and Babcock and Stebbins (1937), whilst citing cases in *Youngia* where grain size increases with higher chromosome number, also state (p. 77) that "the average length of stomata in *lanata* is 26 μ and in *fusca* 33 μ; the average diameter of pollen grains is 29 μ in both species. The larger stomata in *fusca* indicate that it is a tetraploid."

Exactly why *Cakile*, *Plantago* and *Youngia* should prove exceptions to the general rule is not known. Increase in pollen grain size in higher polyploids is presumably the result of the general increase in cell size which takes place, a phenomenon which is also reflected by an increase in the size of stomata, epidermal cells, flowers, etc. Such an increase has also been noted in the Bryophyta, where Wettstein (1937) reported that on the artificial production of a tetraploid moss the spore size increased. However, in this case, after several generations of inbreeding the size of spores in the tetraploid capsules returned to the size characteristic of the diploid, a condition not found in the artificially-produced tetraploids of flowering plants even after thirteen or fourteen generations of inbreeding (Blakeslee, 1941).

It is possible that an increase in pollen grain size is only to be found in auto- or allopolyploids with respect to their diploid progenitors. In the case of *Youngia*, *Y. fusca* is almost certainly not derived by polyploidy from *Y. lanata* (Babcock and Stebbins. 1937, p. 77). In *Cakile*, however, Löve and Löve (1947) state that "it is assumed that it [*C. edentula*] should be regarded as an autopolyploid species" on the evidence of chromosome behaviour at meiosis.

Any attempted explanation of why *Cakile maritima* and *C. edentula* should be an exception to the general rule is mere speculation at present, but it occurs to the author that a clue may be found in their geographical distribution. The two species must have differentiated previous to the last Ice Age, or at least the last glaciation, and must therefore have had a very old genesis one from the other, as compared with many of the undoubtedly post-glacial polyploids or those which have been artificially produced. At the same time, however, it should be noted that as far as is known the chromosomes of *C. edentula* have only been counted and studied in plants from Iceland, a very small part of the total geographic range of the species, and that it is not yet known whether the tetraploid *C. edentula* is in fact the autotetraploid of the diploid *C. maritima*.

SUMMARY.

The possibility of using pollen grain size for differentiating between *Nasturtium officinale* R. Br. sens. str. and *N. microphyllum* Boenn. ex Rchb., and between *Cakile maritima* Scop. and *C. edentula* (Bigel.) Hook. was investigated.

Pollen grains from individual specimens vary considerably in size and, after being tested, a standard sample of ten grains from each specimen was found sufficient to represent the variation.

It was found possible to distinguish between the two species of *Nasturtium* by both the length and breadth of the pollen grains; the dimensional ranges are given. Hybrids between the two species possess pollen which is mostly abortive.

Several new vice-comital records for the species and hybrid are given for Britain, and new records for other countries in the case of *N. microphyllum* and the hybrid.

It proved impossible to differentiate between the species of

Cakile by using pollen grain size; this is an apparent exception to the general rule that increase in ploidy is reflected by an increase in pollen grain size. Two other possible exceptions are cited and possible explanations suggested.

ACKNOWLEDGMENTS.

Grateful acknowledgment for the loan of specimens of *Nasturtium* is made to the Director, Royal Botanic Gardens, Kew, and of *Cakile* to the Curator, The Herbarium, University of Cambridge. I would also like to thank Mr. D. M. Henderson for drawing my attention to the paper by Harter and to Mr. B. L. Burtt for criticism of the manuscript.

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A SUB-LITTORAL SURVEY OF THE LAMINARIACEAE OF LITTLE LOCH BROOM.

By F. T. WALKER.
(Institute of Seaweed Research, Musselburgh.)

(Read by title, 18th November 1954.)

Little Loch Broom is a deep indentation, nine miles in length, running inland in a north-west to south-east direction, in the mountainous north-west mainland of Scotland. The loch has been surveyed from low-water mark, ordinary spring tides, down to 10 fathoms (60 feet or 19 metres) over the northern zone (kilometre grid nos. 199 to 203) and the southern zone (kilometre grid nos. 197 to 202). The sub-littoral zone of the loch from low-water mark to 5 fathoms is steeper on the southern side than on the northern side, but from 5 to 10 fathoms this order is reversed.

The survey was carried out during June 1954 from the motor vessel *Teresa*, and random quadrat sampling by spring-grab, with an intensity of 100 quadrats per square kilometre, was employed (Walker, 1947, 1950, 1952). All depths were measured to the nearest fathom.

The fresh weight per unit area, based on all quadrats whether they contained Laminariaceae or not (*i.e.* the density), and the algal cover (the number of quadrats which brought up Laminariaceae expressed as a percentage of the total quadrats) for each fathom interval of depth are given in Table I.

It will be seen that both density and cover suffered regression with increasing depth although such regressions were not regular. The relationship between the density and the cover found in Orkney and south-east, south-west and north-east Scotland (Walker, 1954) does not apply in Little Loch Broom.

The ratio of species found at various depths is expressed as a percentage of the fresh weight in Table II.

Laminaria saccharina dominates the northern zone at all depths, while *L. cloustoni* dominates the southern zone, but the dominance of this species gives place to that of *L. saccharina* in the deeper water, where the slope of the seabed of the southern zone becomes less steep.

Table I.

Depth (Fathoms) L.W.M.O.S.T.†	Mean Density (lb./sq. yd.).*		Cover (per cent.).	
	Northern Zone.	Southern Zone.	Northern Zone.	Southern Zone.
0	3·1	3·3	53	50
1	5·7	6·0	80	81
2	5·3	6·9	80	84
3	5·3	2·3	80	62
4	1·9	1·3	50	60
5	1·4	1·1	47	25
6	0·9	0·9	60	38
7	0·9	0·5	29	33
8	0·7	0·7	31	35
9	1·0	0·1	73	6
10	0·3	0	20	0
Master mean 0–10 fathoms	2·4	2·1	55	43

* To convert lb./sq. yd. to kg./sq. metre multiply by 0·54.
† L.W.M.O.S.T. Low-water mark, ordinary spring tides.

Table II.

Depth (Fathoms) L.W.M.O.S.T.	Northern Zone.			Southern Zone.		
	Laminaria cloustoni.	Laminaria saccharina.	Saccorhiza bulbosa.	Laminaria cloustoni.	Laminaria saccharina.	Saccorh bulbos
0	8	92	..	87	13	..
1	29	71	..	48	29	23
2	12	88	..	55	32	13
3	29	71	..	46	51	3
4	53	47	..	20	70	10
5	21	79	..	35	65	..
6	21	79	..	64	36	..
7	23	77	..	25	75	..
8	..	100	..	42	58	..
9	..	100	..	..	100	..
10	..	100	..	..	100	..
Whole survey as a unit 0–10 fathoms, inclusive.	21	79	..	53	36	11

It was found that *Laminaria saccharina* on the northern zone was established with a greater number of plants per unit area at all depths than on the southern zone. From 1 to 9 fathoms, inclusive, the mean weight of individual plants and the number of plants per unit area were:

Northern zone, 0·52 lb./plant (235 gm.) 8·6 plants/sq. yd. (10·2/sq. metre).
Southern zone, 0·44 lb./plant (200 gm.) 5·5 plants/sq. yd. (6·6/sq. metre).

On the other hand, *Laminaria cloustoni* was found on the southern zone with a greater number of plants per unit area than on the northern zone. From 0 to 4 fathoms inclusive, the weight/plant and the plants/unit area were:

Northern zone, 0·69 lb./plant (313 gm.) 6·7 plants/sq. yd. (8·0/sq. metre).
Southern zone, 1·00 lb./plant (454 gm.) 7·6 plants/sq. yd. (9·0/sq. metre).

Laminaria saccharina covers the northern zone with more and heavier plants than the southern zone, while *L. cloustoni* covers the southern zone with more and heavier plants than the northern zone. Many quadrats contained mixed species of Laminariaceae, but only those containing one species have been used for computing plant weights and numbers. *Saccorhiza bulbosa* was found on the southern zone but not on the northern zone. *Laminaria digitata* was not found; this species was almost absent from Loch Ewe and Gruinard Bay, two nearby localities which were also surveyed during 1954.

The tidal rise is more than two fathoms in Little Loch Broom and so it was possible for the survey vessel to sample above low-water mark. A few quadrats brought up several plants of *Laminaria cloustoni* growing above low-water mark on both northern and southern zones; these plants are exposed daily during spring tides.

If we base our calculations only on those quadrats which contained laminariae, then the mean density from low water down to five fathoms over the northern zone is 5·8 lb./sq. yd. and, over the southern zone, 5·9 lb./sq. yd.; the standard error of these densities is 13 and 14 per cent. respectively. The greater part of the laminarian vegetation of the opposite sides of Little Loch Broom therefore showed little quantitative difference during the period of the survey, although appreciable differences in the ratio of species, the weight and number of plants and the area covered.

Of the two sides of the loch under review the southern is the more exposed, and this factor should not be overlooked in seeking reasons for the differences indicated above; nevertheless the steeper gradient of the upper 5 fathoms of the southern zone would discourage the accumulation of deposits and these, falling to lower levels, would leave a stable substratum for the establishment of *Laminaria cloustoni*.

The corresponding northern zone with a contour of lesser gradient would allow the formation of a substratum of pebbles and large stones, which the annual, prostrate *Laminaria saccharina* will more readily colonise. On the other hand, *Laminaria cloustoni*, an upright plant with a rigid stipe, requires large boulders and rock for its establishment and growth to maturity over several years.

The calculated quantity of Laminariaceae over the whole survey area was 4340 tons.

This survey is part of the programme of research of the Institute of Seaweed Research.

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NOTES ON SOME UNCOMMON ALGAE FROM LOCHS IN KINROSS, PERTHSHIRE AND CAITHNESS.

By A. J. BROOK.
(Brown Trout Research Laboratory, Pitlochry, Scotland.)

(Read by title, 16th December 1954.)

The following notes relate to algae found during the course of researches carried out at the Brown Trout Research Laboratory, and, as with those reported in an earlier communication (Brook, 1954), they are all either new records for, or of rare occurrence in, the British Isles. The locality of the lochs mentioned is indicated by the full National Grid Reference, given after each is named in the text for the first time.

ISOKONTAE.

CHLOROCOCCALES.

1. CHARACIUM LIMNETICUM Lemm. (Text-fig. 1, 1.)

Frequent on the filtering combs and in the body cavities of *Daphnia hyalina* var. *lacustris* Leydig in Loch Moraig, Perthshire (27/908666), during June and July. Whilst many typical specimens regularly fusiform and lunate in outline have been observed, many short cells of irregular shape were also found. Often groups of cells tend to form fan-shaped clusters within the body cavity. Cells 40–90 μ l., 6–9 μ br. Also present in the summer plankton of Loch Shurrery, Caithness (39/044555).

2. PEDIASTRUM KAWRAISKYI Schmidle. (Text-fig. 1, 2.)

A form differing from the type species in the possession of clathrations between the inner cells, and also in having granular cell walls, was rare in plankton samples from Loch Shurrery collected in May 1950. All coenobia were 32-celled, with cells 15–25 μ diam.

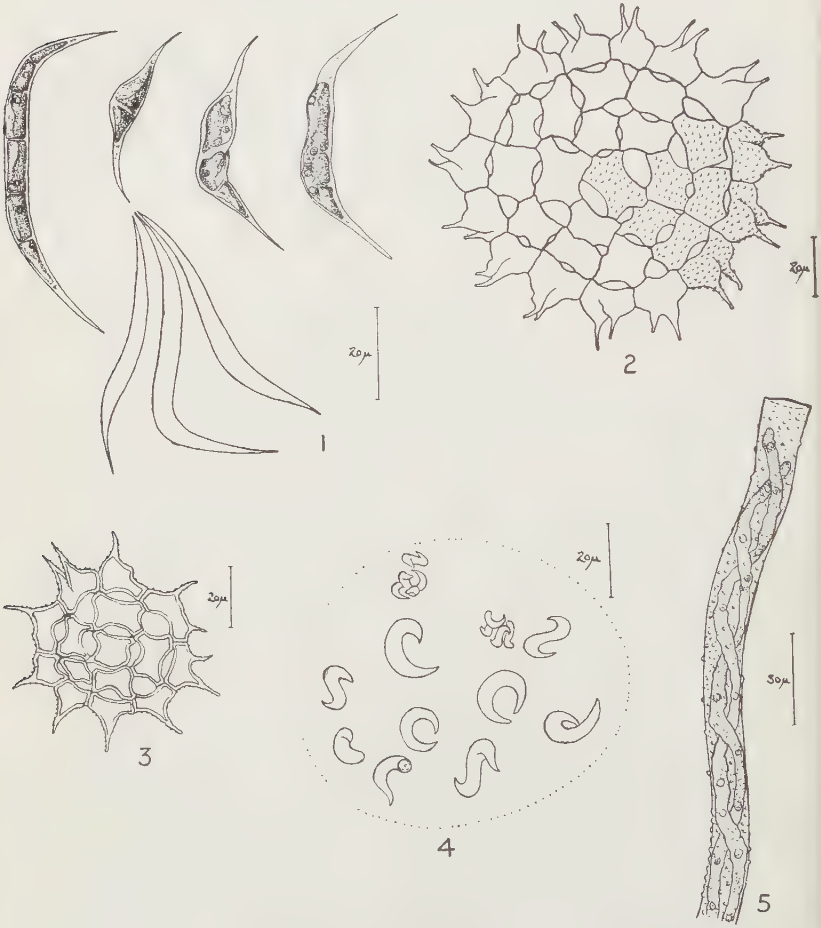
An unusual 15-celled *Pediastrum* coenobium was found in a sample from Loch Shurrery taken in September 1950 (text-fig. 1, 3). In this, the inner cells were quadrate, with lens-shaped spaces between them, while the peripheral cells were of three types:

(*a*) 4 cells with outer margins extended to form a single projection, as in *P. simplex*;

(b) 4 cells showing various stages in the development of a second process (cf. *P. duplex*);

(c) 1 cell with two fully developed projections, but which are not lying in the same plane, as in *P. kawraiskyi*.

Dr. Gunnar Nygaard, to whom drawings of this individual have been shown, has commented: "At first I considered it to be a teratological form, but alternatively it may be a colony subjected to very variable



Text-fig. 1.

1. Characium limneticum Lemm.
2. Pediastrum kawraiskyi Schmidle.
3. Pediastrum sp. (see text).
4. Kirchneriella lunaris var. irregularis G. M. Smith.
5. Genicularia elegans West & West.

environmental factors, perhaps extreme life conditions. If one assumes the latter, this colony seems to indicate that the number of processes on the peripheral cells is a character of but little taxonomic value, apparently a mere modification."

3. LAGERHEIMIA GENEVENSIS Chod.

Occasional in the winter plankton of Loch Leven, Kinross (37/145020); maximum in January of 30 cells per ml.

4. KIRCHNERIELLA LUNARIS var. IRREGULARIS G. M. Smith. (Text-fig. 1, 4.)

Rare in the plankton of Loch Shurrery in June and July 1950. Cells up to 15 μ l. and 5 μ br., with apices characteristically twisted (see Prescott, 1951, p. 258 and pl. 58, fig. 4). A new record for Britain.

5. BOTRYOCOCCUS PROTUBERANS West & West.

Frequent in Loch Chaluim, Caithness (39/022519), in June and July. Previously recorded only in plankton from lochs in the Hebrides (West and West, 1905; Lind, 1952).

CHAETOPHORALES.

1. DICHRANOCHAETE RENIFORMIS Hieron.

Small numbers of this alga have been found attached to glass slides throughout the year in Lochs Choin (27/688679), Kinardochy (27/775550) and Dunmore (27/921590).

CONJUGATAE.

1. GENICULARIA ELEGANS West & West. (Text-fig. 1, 5.)

Occasional filaments of this alga, previously recorded only from the plankton (see West and Fritsch, 1932, p. 241), have been found from time to time attached to *Myriophyllum spicatum* in Loch Dunmore, some filaments consisting of as many as 9 cells. Cells mostly 16·5 μ br., though sometimes as narrow as 13·5 μ, increasing to 17·5 μ (a few to 20 μ) at the apices; cells 290–400 μ l. Never more than 2 chloroplasts per cell observed, and usually making 3 turns of the cell. Cell walls for the most part densely and minutely granulate, but differing from original description (West and West, 1904, p. 36, pl. v, figs. 1 and 2) by the presence of coarse, irregularly disposed granules on all cell walls.

2. Staurastrum pseudopelagicum West & West. (Text-fig. 2, 1.)

An unusual specimen of this desmid was found in the plankton of Loch Shurrery in July 1950. This desmid was originally described (West and Carter, 1923, p. 107) as possessing semicells whose angles are produced to form short, stout, diverging processes tipped with 2 strong diverging spines, though they record (p. 108) that G. M. Smith observed some British specimens with 3 spines. The Loch Shurrery plant had processes in one semicell tipped with 2 spines and in the other with 3 spines.

CHRYSOPHYCEAE.

1. Ochromonas verrucosa Skuja (see Huber-Pestalozzi, 1941, p. 171, Taf. XLI, Abb. 230a).

A few individuals amongst filamentous algae from Loch Choin in September. Cells 22–25 μ l., 18–19 μ br. A new British record.

2. Chrysosphaerella longispina Lautb.

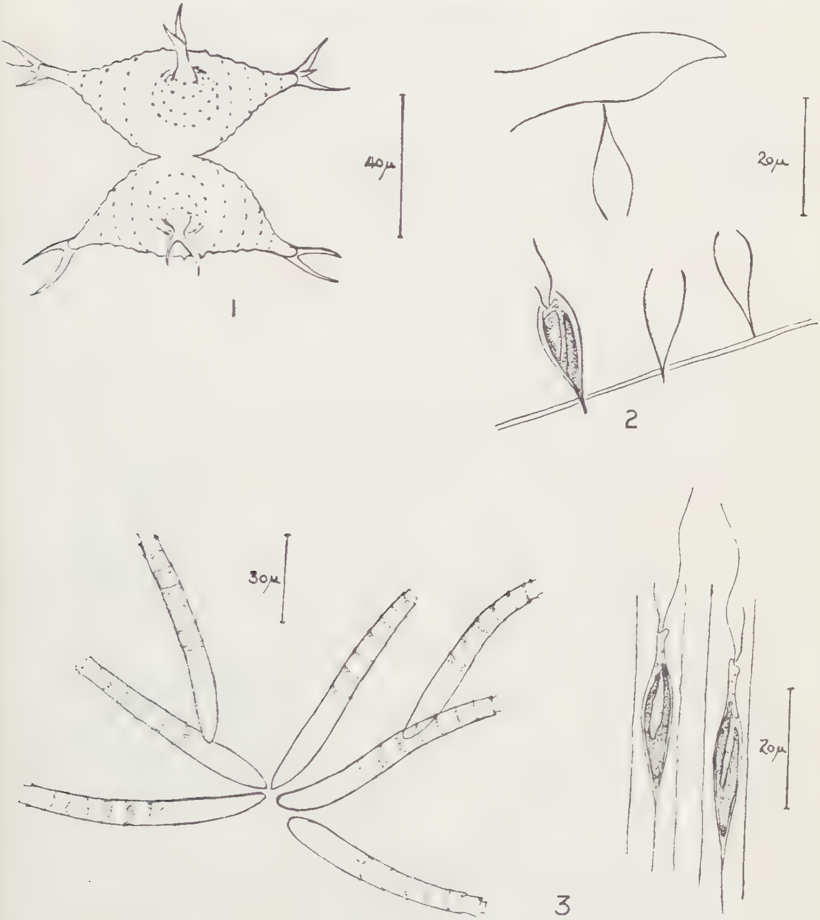
Rare to occasional throughout the year in Loch Dunmore, though most frequent in November and December when the plankton consists mainly of Chrysophyceae, dominated by *Synura uvella* and *Uroglena americana*, but in which *Eudorina elegans* and *Botryococcus braunii* are also abundant. Although Conrad (1941) and Skuja (1948) record this alga as a summer or autumn species, it is of interest to note that it persisted even under ice in Loch Dunmore when water temperatures were between 1–3° C., a fact which tends to confirm Lund's view (1949) that the chemical constitution of the water is probably more important than temperature in influencing the seasonal distribution of the Chrysophyceae. Colonies usually 40 μ diameter without processes, which are from 25–30 μ 1.; cells 8–10 μ diam. Cyst formation observed in sample collected under ice in January; cysts 12·5 μ diam.

3. Dinobryon utriculus var. acutum Schiller. (Text-fig. 2, 2.)

Frequent on filaments of *Oedogonium punctato-striolatum* and other *Oedogonium* spp. in Loch Choin between June and October. One individual found on envelope of *Dinobryon sertularia*. Envelopes 20–22 μ l., 6·5–7·5 μ br. A new British record.

4. Hyalobryon ramosum Lautb. (Text-fig. 2, 3.)

Large colonies present on glass slides from Loch Choin, Loch Dunmore and Lochan an Daim more or less throughout the year.



Text-fig. 2.

1. Staurastrum pseudopelagicum West & West.
2. Dinobryon utriculus var. acutum Schiller.
3. Hyalobryon ramosum Lautb.

The "growth rings" on the envelopes of this alga are very indistinct in living or unstained material, and can only be seen clearly by staining with methylene blue. Lauterborn's original drawing (see Huber-Pestalozzi, 1941, Taf. LXXI, Abb. 327a) indicates that these "rings" are all markedly flared out from the envelope. In the Scottish plants, however, this only applies to the uppermost 2 or 3 rings, the older, lower ones lying close to the envelope.

5. Pseudokephyrion undulatum (Klebs) Pascher.

Groups of 10 to 12 individuals have been found loosely attached by their posterior ends to glass slides, with *Hyalobryon ramosum*, in Loch Dunmore between November and February. While attached to this substratum the individuals swayed gently from side to side but swam away very actively when detached.

Envelopes 25 μ l., 15 μ br.; 7 μ br. at mouth. A new British record.

DINOPHYCEAE.

1. Cystodinium steinii Klebs.

Very rare among *Myriophyllum spicatum* in Loch Dunmore in November. Cells 75 μ l., 30 μ br.; protoplast with well-marked transverse and short longitudinal furrows; 62 μ l., 27 μ br.

MYXOPHYCEAE.

1. Chroococcus limneticus var. distans G. M. Smith. (Text-fig. 3, 1.)

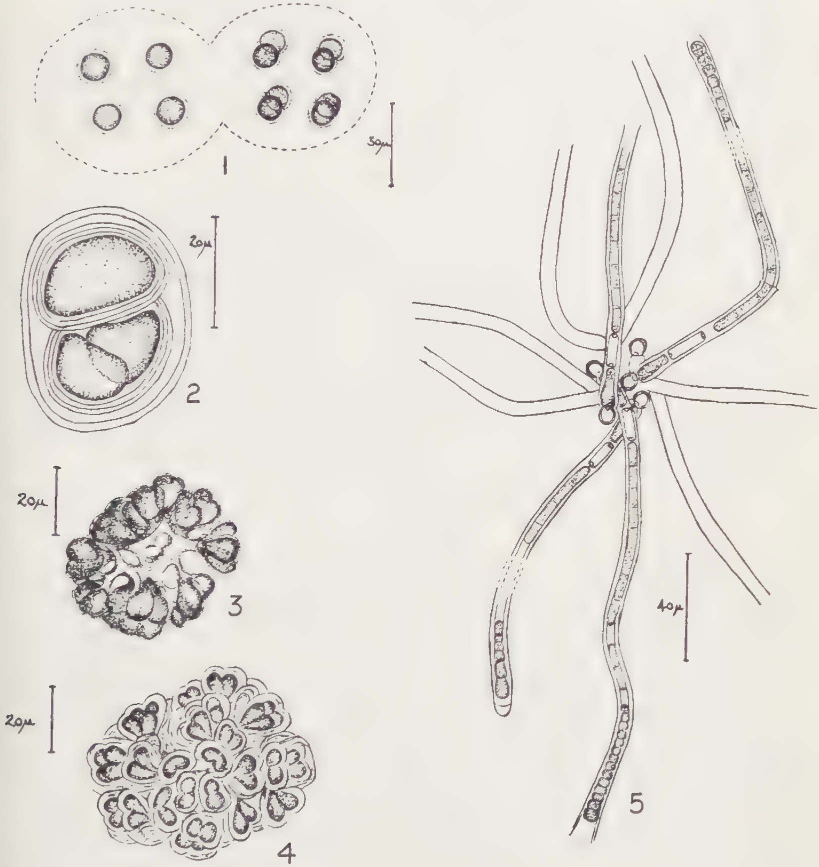
Frequent with the type species in the plankton of Loch Shurrery from July to October. This variety differs from the species by its widely separated cells, or groups of cells. The cells are mostly 7–8 μ diam. (some up to 12 μ), with well-defined sheaths 1 μ br. Recently recorded from Wales (Woodhead and Tweed, 1954).

2. C. tenax (Kirch.) Hieron. (Text-fig. 3, 2.)

Very rare in the plankton of Loch Scye, Caithness (39/005555), in July. Colony 45 μ l., 30 μ br., with cells 12–15 μ diam. Sheaths enclosing individual cells very strongly lamellate, 2·5 μ thick; lamellae of outer sheath enclosing groups of cells less distinct and up to 4·5 μ thick. A new British record.

3. Gomphosphaeria aponina var. cordiformis Wille. Text-fig. 3, 3.)

Rare in the plankton of Loch Shurrery during July and August with the type species. Cells heart-shaped and borne at the ends of distinct, stout, radiating gelatinous strands. Colonies 45 μ diam., with cells 6 μ br., 9 μ l. A new British record.



Text-fig. 3.

1. Chroococcus limneticus var. distans G. M. Smith.
2. Chroococcus tenax (Kirch.) Hieron.
3. Gomphosphaeria aponina var. cordiformis Wille.
4. Gomphosphaeria aponina var. delicatula Virieux.
5. Microchaete tenera Thuret.

4. G. aponina var. delicatula Virieux. (Text-fig. 3, 4.)

Also rare in Loch Shurrery in July and August. The identification of this variety, which is a new British record, has kindly been confirmed by Dr. G. Nygaard. He recorded this variety in material from South Africa (Nygaard, 1932), and his illustrations agree closely with the present plants (see also Huber-Pestalozzi, 1938, Taf. XIII, Abb. 39d). Dr. Nygaard writes: "The measurements of the cells agree very well with those given by Geitler in Rabenhorst's Kryptogamenflora (1932, p. 246). The special teguments (spezialhulle) of your specimens are rather thick, a character lying, however, within the limits of variability for this blue green alga." Colonies 50–80 μ diam., cells 7·5 μ l., 4 μ br. and enclosed in mucilage sheaths up to 2 μ br.

6. MICROCHAETE TENERA Thuret. (Text-fig. 3, 5.)

Found amongst filamentous algae from Loch Choin in October. Trichomes up to 700 μ l., 7·5 μ br., including their distinct mucilage sheath. Cells 7–8 μ l., 4·5 μ br. at the base of the trichome, rapidly tapering to 3 μ br. for most of the remaining length though enlarging again at the apex to 6–7 μ br. Basal heterocysts spherical 6 μ diam., intercalary heterocysts 3·5 μ br., 12–13 μ l. No constriction between cells in the basal region of the trichomes, though constrictions are well marked towards the apex, where the cells become barrel-shaped. A new British record.

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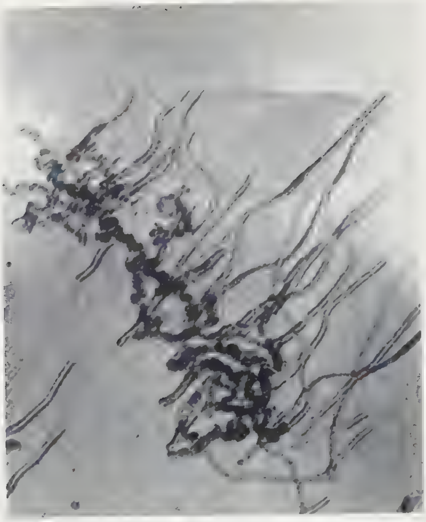

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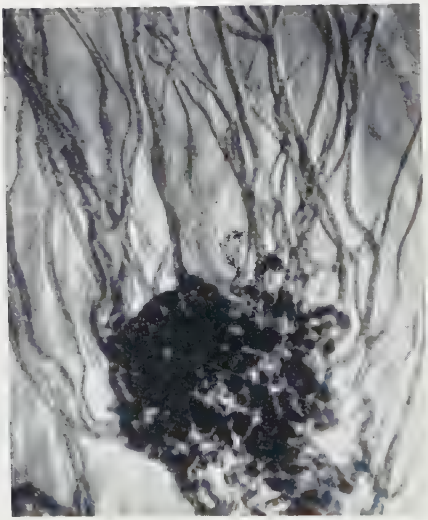


B

ARYA BHUSHAN GUPTA. [*To face p.* 317.

A NEW SPECIES OF SEGUENZEA (S. ANTHONYI SP. NOV.).

By ARYA BHUSHAN GUPTA
(Department of Botany, University of Edinburgh.)

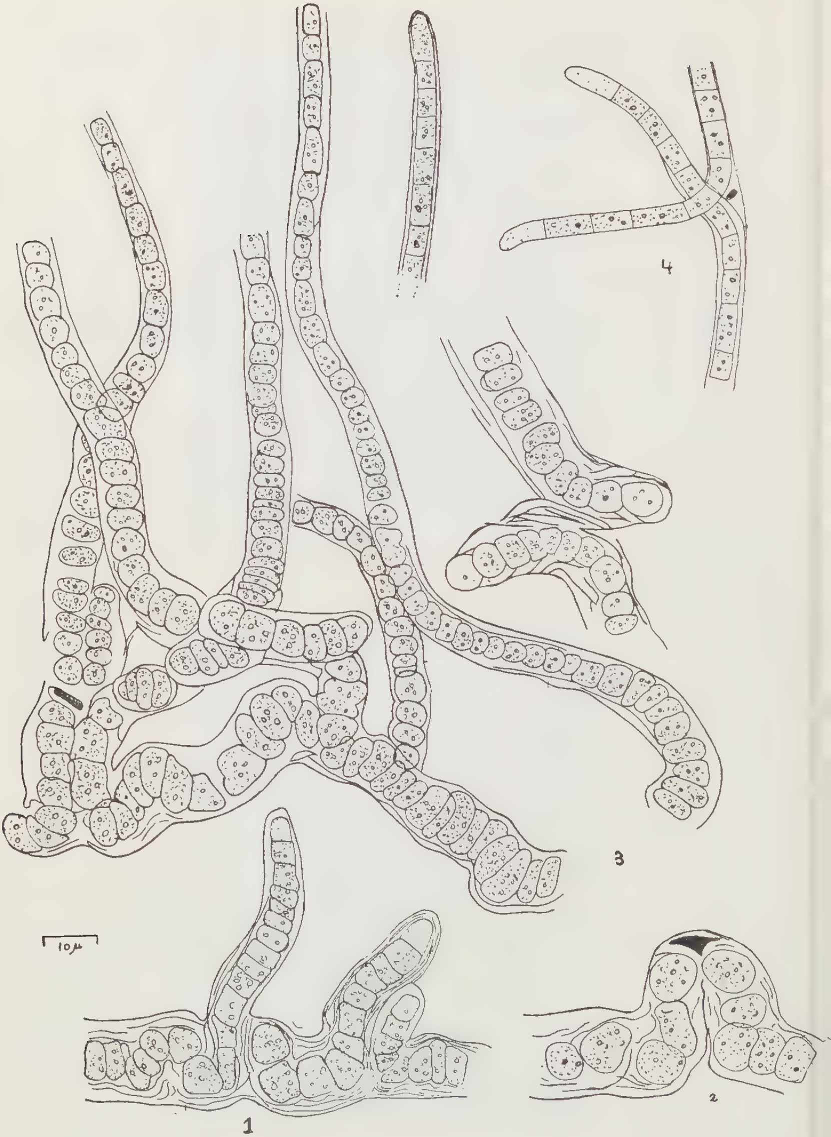
(With Plate XI.)

(Read by title, 16th December 1954.)

While investigating the algal flora of a rice field in India, a form appeared in one of the soil cultures. This was obtained in uni-algal culture, and the following is a detailed description of it.

The alga forms bluish or dark bluish cushions of about 1 mm. in height, and the thallus is markedly differentiated into creeping and erect filaments (Plate XI, A). The former are somewhat contorted and in old cultures form a very compact layer (Plate XI, B). They are 8–18 μ broad with a firm sheath 1–4 μ thick, which may exhibit distinct striations (text-fig. 1, 1) and may turn yellowish or yellowish brown in old filaments. It does not stain blue with chlor-zinc iodide but stains readily with ruthenium red. The cells are distinctly constricted at the transverse walls and may be quadratic or variable in shape and usually much shorter than their breadth: 6–10 μ broad and 2·5–7·5 μ long (text-fig. 1, 1 and 3). The pseudobranches are single or geminate, and may show characteristic loop formation (text-fig. 1, 2). Some grow along the surface of the medium and resemble the parent filaments, while others grow erect. The erect filaments are long and usually show pronounced tapering at the base but are of more or less uniform thickness above (text-fig. 1, 3 and 4). These are 3–6·5 μ broad with a thin but firm and hyaline sheath, and exhibit frequent, usually geminate, pseudobranching (text-fig. 1, 4). The cells at the base of the older branches are short and appear distinctly torulose, but are as long as broad, or longer above, and are unconstricted at the transverse walls: 2–6 μ broad and 4–8·5 μ long. The cell contents are granular, except for the terminal cell which is more or less homogeneous.

The propagation of the alga takes place by hormogonia. These are produced very profusely, and their formation is facilitated by degeneration of cells at intervals in the filaments. Such degenerating cells may also occur in relation to pseudobranches. Spores and heterocysts were observed neither in soil culture nor in cultures on agar.



Text-fig. 1.—1. Old prostrate filament showing striated sheath and pseudobranching. 2. Creeping filament showing loop formation. 3. Part of the thallus. 4. Part of the erect filament showing geminate branching.

The form resembles *Plectonema* in the absence of heterocysts and the occurrence of single or geminate pseudobranches, but differs in the marked differentiation of the thallus into creeping and erect filaments. In the latter character it resembles *Spelaeopogon* and *Seguenzea*, but differs from the former in reproducing by hormogonia and not by hormocysts. The form differs from *Seguenzea sicula* and *S. minor* in the absence of heterocysts, compact arrangement of the contorted creeping filaments, greater differentiation in the breadth of the creeping and erect filaments and in the pronounced tapering of the erect filaments at the base. It may therefore be considered as a new species of *Seguenzea*, *S. anthonyi* sp. nov. The type specimen of this alga is kept at the Royal Botanic Garden, Edinburgh.

DIAGNOSIS.

Thallus pulvinos atro-coeruleos 1 mm. altos formans, parte una procumbente parte altera erecta. Filamenta procumbentia 8–18 μ lata, compacta et contorta, vaginis 1–4 μ latis fere semper striatis, cellulis 6–10 μ latis, 2·5–7·5 μ longis. Filamenta erecta 3–6·5 μ lata, vaginis tenuibus sed firmis, cellulis 2–6 μ latis, 4–8 μ longis. Heterocystae atque sporae desunt.

I wish to express my thanks to Sir William Wright Smith for providing the necessary facilities for work.

Notes on the Vegetation of Iceland.

By D. N. McVean.
(The Nature Conservancy, Edinburgh.)

(Read by title, 7th January 1955.)

INTRODUCTION

According to Löve (1951) only a small part of Iceland is as yet botanically known to the same extent as comparable parts of northern Europe, and during the past decade 25 new species of higher plants have been discovered. Nevertheless, in spite of the difficulties of the terrain a number of vegetational studies have been carried out. The main published works are included in the references, and fig. 1 indicates approximately the regions that have been covered.

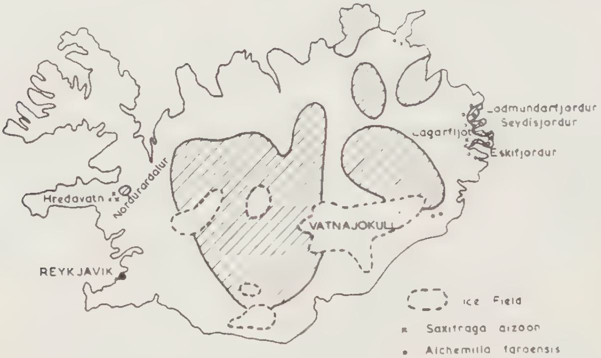


Fig. 1.—Vegetation studies have been carried out mainly in the shaded areas.

As in Norway there has been a tendency to neglect the coastal regions owing to the fact that they do not present such large areas of uniform vegetation nor such precise delimitation of the various associations. It is mainly to the coastal regions in the neighbourhood of Seydisfjordur, Lodmundarfjordur and Eskifjordur that these notes refer. The areas of Nordurardalur studied lie on the edge of the central highlands. Vegetation analyses were not carried out systematically, and the greatest attention was given to the well-defined communities, and especially to those showing a

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real or fancied affinity with Scottish mountain vegetation. In the almost complete absence of adequate descriptions of the latter, direct comparisons will not be attempted here, though studies at present being carried out by the Scottish staff of the Nature Conservancy are revealing hitherto unsuspected similarities and it is hoped that data can be published shortly. No attempt has been made to fit the species lists of Table I into any of the 261 plant associations recognised by Steindórsson (1951), though this could be done for many of them.

The method employed in listing areas of homogeneous plant cover is essentially that of Braun-Blanquet (1932), but the indices of "frequency-cover" that have been used are those of Domin (Poore, 1955) and are as follows:

10	Over 90 per cent. cover.
9	75–90 per cent.
8	50–75 per cent.
7	33–50 per cent.
6	25–33 per cent.
5	*c.* 20 per cent.
4	*c.* 5 per cent.
3	Less than 5 per cent. cover but well distributed.
2	Less than 5 per cent. cover and sparsely distributed.
1	Only one or two individuals per plot.
+	Only occurring outside the minimal area plot.

ENVIRONMENT.

A brief summary may first be given of the environmental factors to be considered in Iceland, though a much fuller account is to be found in Thoroddson (1914).

The climate of coastal Iceland at sea-level is not markedly different from that at 2000 feet in Scotland, apart of course from the differences in day length. Precipitation is greatest in the south-east in the region of the ice-field of Vatnajokul, where it is 60 inches per annum. The mean winter temperature of the eastern coastal zone is in the neighbourhood of 0–1° C., and that of the central plateau −7° C. Mean summer temperature of the different regions varies from 7–9° C. The firn line on the east coast lies at over 3000 feet and the tree or scrub limit at about 1000 feet. Prevailing winds are from east and north.

The flora is small, comprising only about 585 species of vascular plants, and there are relatively few non-British species. From the plant geographical and sociological standpoints, Iceland occupies a vital position midway between the Old and New Worlds, and increasing attention is being given to the problems of distribution and sub-speciation at present.

All districts referred to in the present paper lie within the region of the older volcanic rocks, which are of much the same age and lithology as those of Skye and Mull. Soils are mainly derived directly from the parent lavas, or their glacial products, and are thus extremely uniform. Solifluction and wind drift are virtually universal, so that leaching effects are small and pH values generally from 5 to 7. Peat formation takes place readily enough, but this is seldom free from the influence of mineral-charged ground water, and the more acid raised and blanket bogs are absent.

The delimitation of the plant communities is therefore determined not so much by the soil type as by the water content, angle of slope, exposure, thickness of snow cover, time of snow melt and extent of wind erosion, many of which are interlinked. The liability of the soil to frost action can be judged by the distribution of stone polygons, which are abundant and present even at sea-level in places. These show a mesh size varying from a few inches on a substratum of small particle size to one of several yards where large stones and boulders are involved. In the neighbourhood of melting snow, or after heavy rain, the extent of soil disturbance and the rate of downhill sludging are seen to be considerable.

EFFECT OF SNOW COVER.

Snow cover has a dominating influence on the dry-ground vegetation of the country. The main factors to be considered are altitude, mean depth of snow cover from year to year, the mean duration of snow cover and the summer water content of the soil. At any altitude very exposed ground is blown clear of snow and undergoes a certain amount of solifluction and sand blasting. The communities here are open, and consist of tussock and mat plants such as *Dryas*, *Viscaria alpina*, *Kobresia myosuroides*, *Luzula spicata* and *Festuca rubra*. Where exposure is less severe, and particularly where the ground is stony and free-draining, *Rhacomitrium* heaths, very similar to those on the richer soils of the Scottish mountains, develop. These may be lichen-rich in places, but still have greater affinity with the Scottish moss heaths than with the true lichen heaths of Scandinavia. *Rhacomitrium* heaths, similar to those of our species-impoverished types, also develop on coarse morainic deposits and recent lava fields where frost movement cannot take place.

On the deeper, less stony soils of thin persistent snow cover, *Vaccinium-Empetrum* heath develops. The mat of dwarf shrubs may later suffer wind erosion and be replaced by open *Dryas* communities on the erosion pavement so formed. At higher altitudes the *Vaccinium-Empetrum* heath may occur in slight nivation hollows of the *Dryas* pavement. *Loiseleuria-Empetrum* heath is often found in places of intermediate exposure.

Below the tree line a thick winter snow cover allows birch forest to develop, and the height of the trees or bushes is often closely related to the mean depth of the winter snow (fig. 2) in the same way as the *Parmelia olivacea grenz* in the Scandinavian birch forest. Away from the exposed coasts the birch trees exceed the winter snow in height. At low altitudes even the thickest snow cover melts sufficiently early to give the necessary length of growing period for the birches, willows and associated tall herbs, but increasing altitude leads to a rapid decrease in summer exposure, and typical snow-patch communities develop in the woodlands (fig. 3).

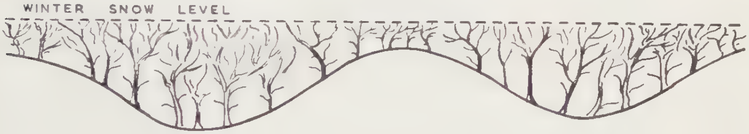

FIG. 2.—Birch forest and winter snow-level in east Iceland.

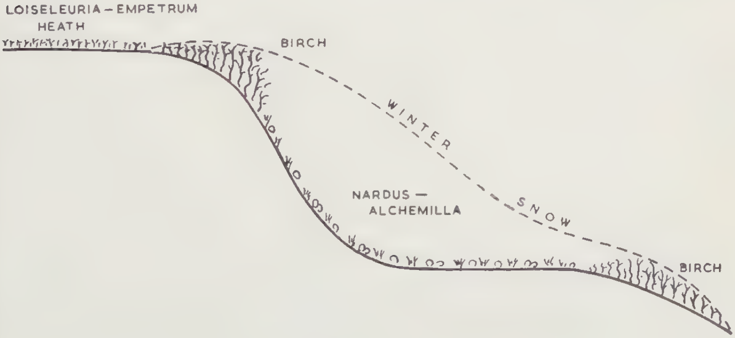

FIG. 3.—Snow-patch vegetation towards upper limit of birch forest.

It should perhaps be made clear that the winter snow-levels indicated in the figures are not based on direct winter observation but are inferred from the state of the vegetation, the distribution of an exceptionally late snow cover in the early summer of 1951, and from personal experience of winter snow distribution in Britain and the published observations of Scandinavian workers.

The plant associations to be found in the snow-patches change with increasing altitude from *Vaccinium-Empetrum* with *Betula nana* and tall herbs, such as *Geranium sylvaticum*, *Ranunculus acris* and *Bartsia alpina*, through *Nardus-stricta-Anthoxanthum* turf, with *Veronica alpina*, *Gnaphalium norvegicum* and *Alchemilla* spp., to those with *Carex bigelowii* and *Salix herbacea* dominant, and finally to *Gnaphalium supinum*, *Sibbaldia procumbens*, *Polytrichum norvegicum* and *Anthelia juratzkana*. Figs. 3 and 4 give an indication of the relationship of some of these species to snow-lie.

Other species such as *Phippsia algida*, *Cerastium cerastioides* and *Deschampsia alpina* are characteristic of those snow-patch communities which are flushed with melt water for the greater part of the growing season.

The communities least influenced by snow cover are those of marsh and bog, where the dominant factors are the amount and seasonal distribution of ground water. Apart from flush communities of the *Carex saxatilis* series, a few *Betula nana* bogs and a single example of *Carex chordorrhiza* bog at Altnaharra in Sutherland, these have few Scottish counterparts.

In the extent to which the country has undergone deforestation, Iceland is more comparable to Scotland than to Scandinavia (*e.g.* birch forest is no longer to be found occupying more than a fraction of the potential area), but in the absence of burning, and the reliability of winter snow cover at low altitudes, conditions are more Scandinavian than Scottish. Much remains to be written of the reasons for the floristic poverty of Scottish mountain vegetation compared with that of comparable areas of Iceland and Norway.

ALTITUDINAL LIMITS.

A striking feature of Icelandic vegetation is that few species have a lower altitudinal limit, most of the mountain plants being found at sea-level. We see this to some extent in the west and north of Scotland, where *Dryas*, *Saxifraga oppositifolia* and *Silene acaulis* are found at sea-level on the coast and again at higher elevations inland, omitting the areas of acid peat at intermediate altitudes. In Iceland there is often complete continuity of distribution from shore to mountain top. On the other hand, many species have a distinct upper limit, generally because they are unable to exist on the violently unstable soils of the high plateau, or because of the presence of permanent snow and ice. At 3000–4000 feet on the coast the common species are *Luzula arcuata*, *Saxifraga oppositifolia*, *S. caespitosa*, *Salix herbacea*, *Silene acaulis*, *Armeria maritima*, *Papaver radicatum*, *Ranunculus glacialis*, *Poa alpina*, *Cardaminopsis petraea*, *Oxyria digyna*, and one or two others. *R. glacialis*, *L. arcuata* and *Arabis alpina* were among the few species not recorded from sea-level on the east coast.

The altitudinal limit of *Calluna vulgaris* on the headland of Skalaness was 500 feet.

SPECIES RECORDS.

The following species were noted outside the range recorded in Grontved (1942). Voucher specimens are lodged in the Herbarium of the Department of Botany at Glasgow University.

LYCOPODIUM ANNOTINUM	Lodmundarfjordur.	In open scrub.
L. ALPINUM	Lodmundarfjordur.	In *Nardus* snow-patches.
ISOETES ECHINOSPORA	Hredavatn.	In the drift line.
EQUISETUM HIEMALE	Lodmundarfjordur.	Marshes in moraine hollows.
SPARGANIUM HYPERBOREUM	Lodmundarfjordur.	Pools behind shore marshes.
ZANNICHELLIA PALUSTRIS	Hredavatn.	In shallow water.
RANUNCULUS GLACIALIS	Nordurardalur, Seydisfjordur, Lodmundarfjordur.	
SAXIFRAGA AIZOON	Skalaness, Seydisfjordur.	Frequent on crags.
S. CERNUA	Nordurardalur, Seydisfjordur, Lodmundarfjordur.	
ALCHEMILLA FAROENSIS	Skalaness.	In most low ground communities.
TRIENTALIS EUROPAEA	Skalaness.	In *Empetrum* heath.
GNAPHALIUM SYLVATICUM	Hredavatn.	In grazed *Nardus*-*Vaccinium* turf.
SUBULARIA ACQUATICA	Hredavatn.	
CORALLORHIZA TRIFIDA	Seydisfjordur.	In *Empetrum*-*Vaccinium* heath.
CAREX ECHINATA	Seydisfjordur, Lodmundarfjordur.	In grazed marsh.
C. MACKENZIEI	Lodmundarfjordur.	Tables I and III.
C. LIMOSA	Seydisfjordur.	Tables I and II.
C. SUBSPATHACEA	Lodmundarfjordur.	In maritime turf.
HIERACIUM ARCTOCERINTHE Dahls.	Nordurardalur.	Further gatherings of Hieracia are in the hands of Ingimar Oskarsson.

PER-GLACIAL REFUGES.

Among the interesting features of Icelandic plant distribution the isolated occurrences of *Saxifraga aizoon*, *S. cotyledon* and *Alchemilla faroensis* are particularly striking (fig. 1). It has been supposed that the saxifrages remain confined to the neighbourhood of nunatak areas on the east and north-west coasts where they survived the glacial maximum, and that they have since been unable to extend outward from the refuges. *Saxifraga aizoides* is similarly distributed along the east coast but shows signs of having extended its range in post-glacial times. In Norway *S. aizoon* behaves as in Iceland (Hultén, 1950).

Some evidence in favour of the per-Glacial survival of *S. aizoon* was obtained at Seydisfjordur in east Iceland. Plants were discovered growing with a particularly rich assemblage of species, including *S. aizoides*, on the crags of the headland of Skalaness, south-east of Seydisfjordur. This headland, with its marine abrasion cliff of over 1500 feet, affords the juxtaposition of high land and deep water necessary to have ensured a steep seaward gradient on the ice-field with the resultant possibility of a coastal nunatak (Dahl, 1946). Signs of ice action were absent from the rocks of Skalaness above 500 feet although they were apparent at much higher altitudes further up the fjord, and the edge of the cliff itself was clean cut. The crags and ledges of Skalaness at low altitudes could have provided plant habitats at a time when the summit of this and other nunataks, though ice free, would have been completely inhospitable.

TABLE I.

BOG AND FLUSH COMMUNITIES (Flói and Mýri).

1. Seydisfjordur. July 19th. Altitude 500 ft. Gentle slope N.W. Marginal to moss-spring vegetation.
2. Lodmundarfjordur. July 27th. Altitude 150 ft. 5° slope S.W. 10 per cent. moss cover. Height of vegetation 20 cm. Water-table 2 cm. down.
3. Lodmundarfjordur. August 4th. Sea-level. Standing water. Moss cover 20 per cent.
4. Lodmundarfjordur. August 6th. Altitude 600 ft. Level ground. Height of vegetation 20 cm. Litter of *Eriophorum* leaves 4 cm. thick.
5. Hredavatn. August 18th. Altitude 500 ft. Bordering open water. Moss cover 25 per cent.
6. Baula, Nordurardulur. August 19th. Altitude 1000 ft. Level ground. 5 per cent. standing water.
7. Lodmundarfjordur. July 19th. Altitude 600 ft. Level ground. Height of vegetation 10 cm. Water-table more than 40 cm. down but higher seasonally.

TABLE I—*continued.*

Soil Profile.

i. Root mat 4 cm.
ii. Light, dry, spongy, yellow-brown peat 10 cm. pH 5·42.
iii. Fine dark lava sand 4 cm.
iv. Further layers of peat and sand. No sign of leaching or gleying.

All plots 2 sq. m.

	1.	2.	3.	4.	5.	6.	7.
Betula nana	..	..	..	6	6	..	6
B. tortuosa	..	..	..	..	1	..	..
Empetrum hermaphroditum	..	..	..	3	3	..	1
Salix glauca	..	..	..	1	..	3	..
S. herbacea	..	..	..	..	..	..	2
S. lanata	..	..	..	..	..	..	1
S. myrsinites	..	..	..	1	..	1	..
Vaccinium uliginosum	..	..	..	4	3	..	5
Equisetum arvense	..	..	2	..	..	..	..
E. palustre	3	2	..	..	..	..	..
Selaginella selaginoides	3	3	..	..	..	..	2
Carex atrofusca	..	..	..	1	..	3	4
C. bigelowii	3	..	..	..	..	..	3
C. curta	3	..	+	..	..	..	..
C. chordorrhiza	..	..	7	..	..	..	..
C. dioica	..	3	..	..	..	..	..
C. limosa	..	..	2	..	..	..	..
C. lyngbyei	..	..	..	..	..	9	..
C. microglochin	..	2	..	..	..	..	..
C. nigra	..	1	3	+	+	..	..
C. panicea	..	1	..	..	..	..	..
C. rariflora	5	+	..	+	..	..	3
C. paupercula	..	..	7	..	..	..	..
Luzula multiflora	..	..	..	1	..	..	..
Scirpus austriacus	..	8	..	2	6	..	6
Comarum palustre	..	..	..	..	..	1	..
Euphrasia frigida	..	1	..	..	..	..	..
Epilobium alpinum	3	..	..	..	..	..	..
Galium saxatile	..	..	..	..	..	..	1
Geum rivale	2	..	..	..	..	..	..
Habenaria hyperborea	..	..	..	..	..	..	1
Menyanthes trifoliata	..	..	4	..	..	..	..
Montia lamprosperma	..	..	2	..	..	..	..
Pinguicula vulgaris	1	2	..	1	2	..	3
Polygonum viviparum	3	..	..	2	..	3	3
Rhinanthus groenlandicus	1	..	..	..	..	..	..
Thalictrum alpinum	+	4	..	4	..	1	4
Triglochin palustre	..	..	..	1	..	..	..
Viola palustris	5	..	..	..	..	..	..
V. riviniana	..	2	..	..	..	..	..
Acrocladium cuspidatum	..	1	..	..	..	..	..
A. sarmentosum	..	..	..	..	1	..	..
A. stramineum	..	..	..	..	1	1	..

TABLE I—*continued.*

	1.	2.	3.	4.	5.	6.	7.
ANEURA MULTIFIDA	..	..	..	..	1	..	..
BRYUM sp.	6	..	..	..	..	..	..
CAMPTOTHECIUM NITENS	..	..	..	..	..	1	3
CAMPYLIUM STELLATUM	..	..	1	..	..	..	..
CLIMACIUM DENDROIDES	2	..	..	..	..	..	..
CLADONIA SYLVATICA	..	..	..	..	1	..	..
CRATONEURON COMMUTATUM v. FALCATUM	..	..	..	1	1	..	..
DREPANOCLADUS INTERMEDIUS	..	..	..	..	..	..	1
D. REVOLVENS	..	3	2	1	..	..	..
HYLOCOMIUM SPLENDENS	1	..	..	1	..	3	..
HYPNUM GIGANTEUM	..	..	3	..	..	..	..
LOPHOZIA cf. KUNZEANA	..	2	..	..	..	..	..
LOPHOZIA sp.	..	..	..	1	..	..	..
MNIUM CINCLIDIOIDES	1	..	..	..	..	..	..
PELLIA FABROWIANA	1	..	..	..	..	..	..
POHLIA ALBICANS	..	..	1	..	..	..	..
PTILIDIUM CILIARE	..	..	..	1	..	..	..
RHACOMITRIUM CANESCENS	..	..	..	..	4	..	..
RHYTIDIADELPHUS SQUARROSUS	..	3	..	1	..	2	..

Species recorded only as (+): ALCHEMILLA ALPINA (1), A. FAROENSIS (1), A. WICHURAE (1), BARTSIA ALPINA (7), CALAMAGROSTIS NEGLECTA (5), CAREX MACKENZIEI (3), C. ROSTRATA (5), C. VAGINATA (4), ERIOPHORUM SCHEUCHZERI (1), MNIUM PUNCTATUM (6), PHLEUM COMMUTATUM (1).

TABLE II.

NARDUS STRICTA SNOW PATCHES (Grasdaeldir).

1. Lodmundarfjordur. August 6th. Altitude 900 ft. Slightly concave slope 15° S.S.E. Just free of snow. Bryophyte cover 20 per cent.
2. Lodmundarfjordur. As for 1. Bryophyte cover 25 per cent.
3. Lodmundarfjordur. As for 1. Slope of 5° south. Bryophyte cover 50 per cent.
4. Baula. August 19th. Altitude 1000 ft. Concave slope 5° S.E. Height of vegetation 15 cm. See fig. 4.

All plots 1 sq. m.

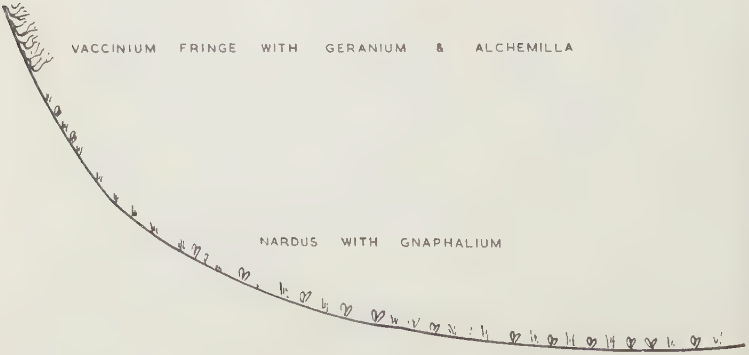

FIG. 4.—*Nardus* snow-bed on Baula (Table II, 4).

Table II—*continued.*

	1.	2.	3.	4.
Calluna vulgaris	..	..	5	..
Empetrum hermaphroditum	2	2	3	..
Loiseleuria procumbens	..	2	..	..
Salix herbacea	3	4	2	..
Vaccinium myrtillus	1	..	..	..
Equisetum arvense	..	..	..	1
Agrostis tenuis	1	1	..	3
Anthoxanthum odoratum	4	..	1	3
Carex bigelowii	..	1	1	..
Deschampsia flexuosa	..	..	..	1
Festuca sp.	3	3	2	..
Juncus trifidus	1	..	..	..
Luzula multiflora	..	..	..	2
L. spicata	1	..	..	..
Nardus stricta	5	4	6	10
Alchemilla alpina	4	..	1	2
A. faroensis	4	..	+	..
Cassiope hypnoides	2	3	4	..
Galium pumilum	1	..	..	3
Geranium sylvaticum	3	..	..	1
Gnaphalium norvegicum	..	..	..	2
G. supinum	4	4	2	..
Polygonum viviparum	..	..	2	2
Potentilla crantzii	1	..	..	..
Sibbaldia procumbens	4	3	3	..
Silene acaulis	2	2	..	..
Taraxacum croceum agg.	..	..	1	+
Thalictrum alpinum	1	..	..	..
Thymus drucei	3	1	..	1
Anthelia sp.	..	1	..	..
Cetraria islandica	..	1	..	..
Cladonia cervicornis	..	..	1	..
C. gracilis v. chordalis	3	1	2	..
C. impexa	..	1	..	..
C. rangiferina	..	1	..	..
C. sylvatica	..	..	1	..
Dicranum fuscescens	2	5	4	..
Lophozia alpestris	3	1	..	..
L. floerkii	..	..	1	..
Peltigera canina	2	..	..	..
Polytrichum juniperinum	+	1	2	..
P. urnigerum	1	..	..	..
Ptilidium ciliare	..	..	1	..
Rhacomitrium canescens	..	..	6	..
Rhytidiadelphus squarrosus	..	..	..	3
Solorina crocea	1	..	..	..
Stereocaulon evolutoides	1	..	1	..
Webera cruda	1	..	..	..

Species recorded only as (+): Galium boreale (4), Hierochloe odorata (4), Rumex acetosa (1).

TABLE III.

SALIX HERBACEA SNOW PATCHES (Grasdidaeldir).

1. Eskifjordur. July 15th. Altitude 1650 ft. Slope 3° N.E. Bryophyte cover 70 per cent. Height of vegetation 9 cm. 1 sq. m. plot.

Soil Profile.

i. Turf 6 cm.
ii. Lava sand 5 cm.
iii. Brown soil 9 cm.
iv. Brown soil with lava pebbles to some depth.

2. Karlfjell, Lodmundarfjordur. July 29th. Altitude 2600 ft. Concave slope 2°–3° S.W. Height of vegetation 1 cm. Bryophyte cover 5 per cent. Stone cover 5 per cent. 0·5 sq. m. plot.

Soil Profile.

i. Red-brown loam 20 cm.
ii. Lava debris.

3. Baula. August 20th. Altitude 2000 ft. South-facing slope. See fig. 5. 1 sq. m. plot.
4. Baula. August 22nd. Altitude 1600 ft. Slope 5° S.E. 1 sq. m. plot. List of Cryptogams incomplete.

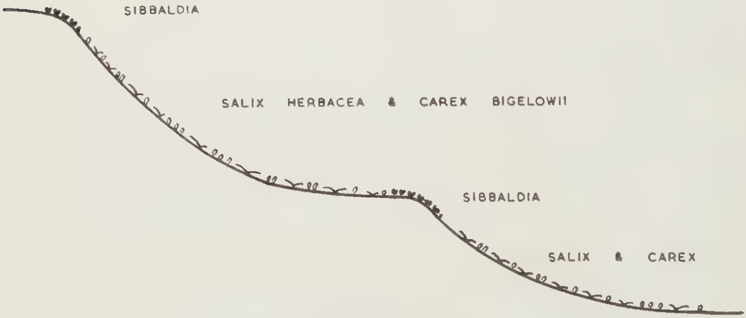

FIG. 5.—*Salix herbacea* snow-bed on Baula (Table III, 3).

TABLE III—*continued.*

	1.	2.	3.	4.
SALIX HERBACEA	7	7	9	8
S. LANATA	2	..	..	..
EQUISETUM ARVENSE	2	..	..	..
E. PALUSTRE	2	..	..	..

Table III—*continued.*

	1.	2.	3.	4.
Agrostis tenuis	2	..	..	..
Anthoxanthum odoratum	..	..	..	2
Festuca rubra	..	1	..	..
Luzula spicata	..	1	..	..
Phleum commutatum	..	2	..	4
Poa alpina	2	1	1	2
Alchemilla alpina	..	..	..	2
A. filicaulis	..	+	..	3
Cerastium cerastioides	+	1	+	..
Gentiana nivalis	..	..	..	1
Gnaphalium norvegicum	..	..	..	2
G. supinum	..	4	1	..
Hieracium alpinum	..	..	..	1
Polygonum viviparum	4	3	1	4
Pyrola minor	..	..	+	1
Ranunculus sp.	..	1	..	..
Sibbaldia procumbens	..	4	1	4
Taraxacum croceum agg.	..	1	+	2
Thalictrum alpinum	..	3	..	..
Veronica alpina	..	1	..	2
Viola palustris	..	3	..	..
Anthelia juratzkana	..	2	..	..
Cetraria islandica	..	..	1	..
Climacium dendroides	1	..	..	..
Drepanocladus uncinatus	5	1	..	..
Peltigera canina	1	2	..	..
Polytrichum alpinum	3	..	5	4
P. norvegicum	..	3	..	..
Rhacomitrium canescens	..	3	+	..
Rhytidiadelphus squarrosus	2	..	..	..
Solorina crocea	..	1	+	..

Species recorded only as (+) Bartsia alpina (2), Cladonia sylvatica (3), Salix glauca (1), Silene acaulis (2), Stereocaulon evolutoides (3), Conostomum tetragonum (3).

Table IV.

BIRCH WOOD AND SCRUB

1. Seydisfjordur. July 20th. Altitude 650 ft. Slope 3° S.S.W. Tree cover 75 per cent. Height of vegetation 50 cm. 8 sq. m. plot.

Soil Profile.

i. Black leaf litter with fungal hyphae 2 cm. pH 4·5.
ii. Alternate bands of brown loam and red-brown clay 20 cm.

2. Hredavatn. August 18th. Altitude 500 ft. Gentle slope to E. Tree cover 60 per cent. Moss cover 30 per cent. Height of vegetation 200 cm. 16 sq. m. plot.
3. Lodmundarfjordur. July 27th. Altitude 150 ft. Level ground. Height of vegetation 45 cm. 16 sq. m. plot.

Table IV—*continued.*

	1.	2.	3.
Betula tortuosa	7	8	8
Empetrum hermaphroditum	..	5	..
E. sp.	3	..	3
Salix lanata	4	..	5
Vaccinium myrtillus	5	3	4
V. uliginosum	3	5	3
Equisetum arvense	3	3	2
Carex nigra	..	1	..
C. cf. vaginata	1	..	..
Deschampsia flexuosa	..	3	+
Festuca rubra	3	..	..
Luzula multiflora	2	3	+
L. spicata	..	1	..
Alchemilla vestita	+	..	+
Bartsia alpina	3	..	+
Campanula rotundifolia	1	..	..
Euphrasia frigida	2	+	+
Galium hercynicum	..	3	..
G. pumilum	3	..	1
G. verum	3	..	3
Geranium sylvaticum	5	+	5
Hieracium sp.	1	1	..
Polygonum viviparum	1	..	..
Ranunculus acris	+	1	2
Rhinanthus groenlandicus	2	..	..
Rubus saxatilis	3	+	2
Rumex acetosa	..	2	..
Taraxacum croceum agg.	3	+	1
Thalictrum alpinum	2	1	..
Trientalis europea	..	3	..
Cladonia pyxidata	..	1	..
C. rangiferina	..	1	..
C. sylvatica	..	1	..
Dicranum scoparium	..	3	..
Hylocomium splendens	1	6	3
Peltigera canina	..	3	..
Pleurozium schreberi	..	1	..
Polytrichum alpinum	..	1	..
P. commune	1	..	2
Ptilidium ciliare	..	1	..
Rhytidiadelphus squarrosus	3	..	3
R. triquetrus	1	1	2
Boletus sp.	..	1	..

Species recorded only as (+): Agrostis tenuis (2), Arctostaphylos uva-ursi (2), Hierochloe odorata (3), Galium boreale (2), Geum rivale (3), Juniperus communis (3), Orchis maculata v. islandica (3), Phleum commutatum (1), Pyrola minor (3), Betula nana (3).

TABLE V.

MOSS HEATHS (Mosaheidi).

1. Eskifjordur. July 16th. Altitude 2350 ft. Slope 10° N.N.E. Top of scree ridge. Moss cover 95 per cent. Height of vegetation 8 cm. Uniform brown soil 3–4 cm. deep over lava rubble. pH 5·5.
2. Eskifjordur. As for 1. Slope N. at 15°. Moss cover 75 per cent. Soil deeper than 1.
3. Seydisfjordur. July 20th. Altitude 2050 ft. On brow of long S.E. slope. Moss cover 75 per cent. Height of vegetation 2 cm.

Soil Profile.

i. Stoneless brown loam, pH 5·0.
ii. Stony loam to considerable depth.

4. Lodmundarfjordur. August 1st. Altitude 2600 ft. Slope 8° S.
5. Baula. August 20th. Altitude 1100 ft. Slope 2° S. Moss cover 75 per cent. Height of vegetation 5 cm.

All plots 1 sq. m.

	1.	2.	3.	4.	5.
CASSIOPE HYPNOIDES	..	..	1	..	..
SALIX HERBACEA	3	4	5	2	3
EQUISETUM ARVENSE	..	..	3	3	3
E. VARIEGATUM	..	..	..	..	1
CAREX BIGELOWII	+	+	5	3	6
FESTUCA RUBRA	2	2	1	..	2
JUNCUS TRIFIDUS	..	..	..	..	2
LUZULA SPICATA	..	..	..	2	..
POA ALPINA	1	1	2	..	..
CERASTIUM ALPINUM	..	1	3	..	2
POLYGONUM VIVIPARUM	3	4	4	4	4
POTENTILLA CRANTZII	..	..	1	1	2
SAXIFRAGA CAESPITOSA	1	..	..	..	..
S. HYPNOIDES	1	..	..	..	..
S. NIVALIS	..	1	..	..	..
S. OPPOSITIFOLIA	4	3	1	..	..
SIBBALDIA PROCUMBENS	..	..	2	..	..
SILENE ACAULIS	+	2	2	1	3
THALICTRUM ALPINUM	..	..	3	3	3
THYMUS DRUCEI	..	..	..	..	1
ANTHELIA sp.	..	1	..	..	..
AULACOMNIUM TURGIDUM	3	2	+	..	..
CERANIA VERMICULARIS	2	..	..	..	+
CETRARIA ISLANDICA	4	2	..	2	2
CLADONIA LEUCOPHAEA	1	..	..	..	..
C. PYXIDATA	1	..	..	..	..
C. SYLVATICA	+	1	..	..	..
C. UNCIALIS	1	+	..	..	..
CLIMACIUM DENDROIDES	..	..	2	..	..
DICRANUM FUSCESCENS	+	4	..	..	..
DREPANOCLADUS UNCINATUS	..	4	2	..	..

TABLE V—*continued.*

	1.	2.	3.	4.	5.
HYLOCOMIUM SPLENDENS	5	7	..	..	4
LOPHOZIA cf. ATTENUATA	..	1	..	3	..
LOPHOZIA sp.	1	..	..	..	..
PANNARIA RUBIGINOSA	1	..	..	..	..
PELTIDEA APHTHOSA v. LEUCOPHLEBIA	3	..	..	..	..
PELTIGERA CANINA	1	1	1	..	..
PLEUROZIUM SCHREBERI	1	1	..	..	..
POLYTRICHUM JUNIPERINUM	1	1	..	..	..
PTILIDIUM CILIARE	1	3	1	1	..
RHACOMITRIUM CANESCENS	..	..	..	+	8
R. LANUGINOSUM	10	5	8	9	+
STEREOCAULON EVOLUTOIDES	1	1	1	5	+
TIMMIA AUSTRIACA	..	2	..	..	..

Species recorded only as (+): ARMERIA MARITIMA (3), BARTSIA ALPINA (4), CLADONIA SQUAMOSA (2), CONOSTOMUM TETRAGONUM (3, 4), EMPETRUM HERMAPHRODITUM (5), FESTUCA VIVIPARA (4), GALIUM HERCYNICUM (5), POLYTRICHUM URNIGERUM (3), SAXIFRAGA HIRCULUS (5), SOLORINA CROCEA (2, 4), SPHAEROPHORUS GLOBOSUS (5).

TABLE VI.

VACCINIUM-EMPETRUM HEATH (Runnaheidi).

1. Eskifjordur. July 17th. Altitude 1500 ft. Back wall of S.W.—facing hollow in open *Dryas* heath. Slope 10°. Height of vegetation 6 cm.

Soil Profile.

i. Leaf litter 1 cm.
ii. Brown, rooty, granular loam 15 cm.

2. Seydisfjordur. July 19th. Altitude 500 ft. Slope 5° N.N.W. Moss cover 10 per cent. Height of vegetation 4 cm.

Soil Profile.

i. Moss litter 10 cm.
ii. Stony brown loam 10 cm.
iii. Fine lava scree.

3. Skalaness, Seydisfjordur. July 23rd. Altitude 100 ft. Slope 2° N.W.
4. Lodmundarfjordur. July 27th. Altitude 300 ft. Slope 12° S.W. Height of vegetation 18 cm.

All plots 1 sq. m.

	1.	2.	3.	4.
BETULA NANA	6	..	..	..
CALLUNA VULGARIS	..	..	3	6
EMPETRUM HERMAPHRODITUM	5	4	8	6
LOISELEURIA PROCUMBENS	2	..	..	4
RUBUS SAXATILIS	..	..	..	3
SALIX GLAUCA	..	2	..	..
S. HERBACEA	+	1	..	..
S. LANATA	..	+	+	2
S. MYRSINITES	..	2	..	+
VACCINIUM MYRTILLUS	..	..	4	5
V. ULIGINOSUM	4	6	6	6

Table VI—*continued.*

	1.	2.	3.	4.
Equisetum arvense	..	..	..	1
E. pratense	..	3	..	..
Selaginella selaginoides	..	1	..	..
Agrostis canina	..	2	..	..
A. tenuis	..	..	1	..
Anthoxanthum odoratum	..	..	..	3
Carex bigelowii	2	..	..	..
Deschampsia alpina	..	1	..	..
D. flexuosa	..	..	2	3
Festuca rubra	3	..	..	1
F. vivipara	..	3	..	..
Juncus trifidus	2	3	..	..
Luzula multiflora	..	3	1	..
Nardus stricta	..	..	1	..
Alchemilla alpina	1	3	+	2
A. vestita	..	1	..	..
Armeria maritima	1	..	..	..
Bartsia alpina	..	3	..	..
Campanula rotundifolia	..	..	1	..
Coeloglossum viride	..	2	..	..
Dryas octopetala	..	3	+	..
Erigeron borealis	..	1	..	..
Galium verum	..	1	..	+
Geranium sylvaticum	..	..	..	3
Hieracium sp.	..	1	..	..
Listera cordata	..	1	..	..
Polygonum viviparum	3	3	1	+
Potentilla crantzii	..	2	..	..
Pyrola minor	1	2	..	..
Ranunculus acris	..	2	..	..
Rhinanthus groenlandicus	..	..	..	1
Rumex acetosa	..	1	..	..
Thalictrum alpinum	1	3	..	..
Thymus drucei	..	+	..	1
Tofieldia palustris	..	1	..	..
Cladonia rangiferina	1	..	..	..
Dicranum fuscescens	..	1	1	..
Drepanocladus uncinatus	3	1	1	..
Hylocomium splendens	..	4	..	..
Lophozia lycopodioides	..	1	..	..
Peltidea aphthosa v. leucophlebia	..	2	..	..
Polytrichum alpinum	..	1	..	..
P. urnigerum	..	1	..	..
Ptilidium ciliare	..	..	1	..
Rhacomitrium lanuginosum	..	1	..	1
Rhytidiadelphus squarrosus	..	2	1	..
Rhytidium rugosum	..	1	..	..

Species recorded only as (+): Alchemilla faroensis (3), Betula tortuosa (4), Luzula spicata (1), Plantago maritima (2), Silene acaulis (1), Taraxacum sp. (2, 3).

Table VII.

LOISELEURIA-EMPETRUM HEATH.

1. Lodmundarfjordur. July 28th. Altitude 650 ft. Level. Moss cover 10 per cent. Height of vegetation 2·5 cm.

Soil Profile.

i. Brown, sandy loam with roots 9 cm. pH 6·2.
ii. Pitchstone gravel, little altered.

Size of plot 2 sq. m.

2. Seydisfjordur. July 27th. Altitude 400 ft. Slope 3° N.W. Height of vegetation 10 cm. Size of plot 1 sq. m.

	1.	2.
Calluna vulgaris	..	5
Empetrum hermaphroditum	5	6
Loiseleuria procumbens	8	7
Salix glauca	1	..
S. herbacea	2	2
Vaccinium uliginosum	+	5
Agrostis tenuis	..	1
Carex bigelowii	..	1
Nardus stricta	..	1

	1.	2.
Polygonum viviparum	1	..
Silene acaulis	1	..
Tofieldia palustris	..	1
Cladonia gracilis v. chordalis	1	..
C. sylvatica	3	..
Dicranum starkei	2	3
Drepanocladus uncinatus	..	2
Stereocaulon evolutoides	1	..
S. vesuvianum	1	..

Species recorded only as (+): Bartsia alpina (2), Betula tortuosa (seedling) (1), Cladonia impexa (2), Equisetum palustre (2), Juncus trifidus (1), Peltigera canina (2), Vaccinium myrtillus (2).

Table VIII.

MOSS SPRINGS (Dý.).

1. Seydisfjordur. July 19th. Altitude 500 ft. Slight slope N.W. Moss cover 100 per cent. Height of vegetation 3 cm.
2. Seydisfjordur. As for 1.

Both plots 0·25 sq. m.

	1.	2.
Equisetum palustre	3	3
Agrostis stolonifera	2	3
Carex bigelowii	3	1
Cerastium cerastioides	2	..
Epilobium alpinum	2	..

	1.	2.
Polygonum viviparum	3	..
Saxifraga stellaris	1	..
Hypnum cordifolium	2	..
H. giganteum	..	10
Philonotis fontana	2	3
Pohlia glacialis	10	2

Species recorded only as (+): Carex rariflora (1), Eriophorum angustifolium (2), Mnium pseudopunctatum (1, 2).

TABLE IX.

OPEN DRYAS HEATH (Melar).

1. Eskifjordur. July 16th. Altitude 500 ft. Slope 3° N.W. Stones and bare soil 50 per cent. Moss cover 25 per cent. Height of vegetation 12 cm. Plot of 4 sq. m.
2. Lodmundarfjordur. July 27th. Altitude 200 ft. Level area of stone polygons. Plant cover 10 per cent. Size of plot 16 sq. m.

	1.	2.
DRYAS OCTOPETALA	2	3
EMPETRUM sp.	1	..
SALIX LANATA	..	1
JUNCUS TRIFIDUS	1	..
KOBRESIA MYOSUROIDES	2	1
LUZULA SPICATA	..	1
ALCHEMILLA ALPINA	+	2
ARMERIA MARITIMA	1	..
CAMPANULA ROTUNDIFOLIA	..	1
CERASTIUM ALPINUM	1	2
C. CAESPITOSUM	1	..
DRABA INCANA	1	..
ERIGERON BOREALIS	1	+
GALIUM PUMILUM	1	2
LEONTODON AUTUMNALIS f. NIGRO-LANATO	..	1
POTENTILLA CRANTZII	1	+
SAXIFRAGA OPPOSITIFOLIA	1	..
SILENE ACAULIS	2	1
SILENE MARITIMA ssp. ISLANDICA	..	2
THYMUS DRUCEI	2	3
VERONICA FRUTICANS	+	1
VISCARIA ALPINA	..	1
CERANIA VERMICULARIS	1	..
CLADONIA PYXIDATA	1	..
CORNICULARIA ACULEATA	2	..
GYMNOMITRIUM CORALLOIDES	..	1
PELTIGERA CANINA	1	..
POLYTRICHUM URNIGERUM	1	..
RHACOMITRIUM LANUGINOSUM	3	2
STEREOCAULON EVOLUTOIDES	3	..

Species recorded only as (+): ANTHYLLIS VULNERARIA ssp. ISLANDICA (2), ARABIS PETRAEA (1, 2), BOTRYCHIUM LUNARIA (1), EQUISETUM ARVENSE (1), EUPHRASIA FRIGIDA (1), POLYGONUM VIVIPARUM (2), STERECAULON PASCHALE (2).

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Report of the Cryptogamic Section, 1954.

By D. M. Henderson.

The sixty-sixth annual autumn foray was held in Edinburgh and district on Saturday, 25th, and Sunday, 26th September. On the first day the woods of Tynninghame were visited. This locality has previously yielded many unusual fungi but, as the list shows, only very common species were found. This was the general experience on both excursions; the wet summer conditions followed by a dry spell in mid-September robbed us of the chance of making unusual finds. Bolton Muir Wood, near Gifford, visited on the second excursion, proved equally disappointing.

Whilst the collections were poor the weather was perfect, so that, on balance, the excursions were highly successful.

The nomenclature of agarics in the list of species collected follows Pearson & Dennis' list.

LIST OF FUNGI COLLECTED.

T=Tynninghame; G=Gifford.

Amanitopsis vaginata, T; fulva, G.
Lepiota cristata, T.
Armillaria mellea, G; mucida, G.
Tricholoma imbricatum, T; vaccinum, G.
Laccaria laccata, T, G; amethystina, T, G.
Mycena galopus, T, G; sanguinolenta, T; fagetorum, G.
Collybia maculata, T, G.
Marasmius peronatus, T, G; androsaceus, T.
Omphalia pyxidata, T; swartzii, T; umbellifera, T.
Hygrophorus hypothejus, G; pustulatus, G; niveus, T; coccineus, T.
Lactarius torminosus, G; plumbeus, G; deliciosus, G; vietus, T, G; quietus, T, G; glycyosmus, T, G; rufus, T, G.
Russula emetica, T, G; fragilis, G; drimeia, G; drimeia var. viridis, G; ochroleuca, T, G.
Cantharellus cibarius, G; tubaeformis, G.
Pluteus cervinus, T, G.
Nolanea staurospora, T, G; cetrata, G.
Pholiota squarrosa, T; aurivella, T; mutabilis, G.
Hebeloma mesophaeum, T.
Flammula penetrans, T, G; spumosa, T.
Galera mycenopsis, G.
Crepidotus mollis, G.
Cortinarius elatior, G; pholideus, G; semisanguineus, G; cinnamomeus var. croceus, G; anomalus, G; hinnuleus, G; paleaceus, G; junghuhnii, G.

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Inocybe geophylla, T, G.
Paxillus involutus, T, G.
Stropharia aeruginosa, T, G.
Hypholoma hydrophilum, G; fasciculare, T. G.
Panaeolus acuminatus, T.
Coprinus comatus, T; atramentarius, T; lagopus, T.
Boletus chrysenteron, T, G.

The following list of bryophytes has been prepared by Miss C. W. Muirhead. Nomenclature and arrangement of mosses follows Richards & Wallace's List, and of the hepatics MacVicar's Handbook.

MOSSES.

Fissidens bryoides, G; taxifolius, G.
Dicranella heteromalla, G.
Dicranum majus, G; scoparium, G.
Leucobryum glaucum, G.
Encalypta streptocarpa, T.
Tortula muralis, T; ruraliformis, T.
Barbula unguiculata, T; convoluta, T.
Grimmia maritima, T; pulvinata, T.
Mnium hornum, G, T; longirostrum, T; undulatum, T; punctatum, T.
Thuidium tamariscinum, G, T.
Acrocladium cuspidatum, T.
Camptothecium sericeum, G, T.
Brachythecium rutabulum, G.
Eurynchium striatum, G, T; praelongum, G; confertum, G.
Pseudoscleropodium purum, G.
Pleurozium schreberi, G, T.
Plagiothecium denticulatum, G, T; undulatum, G.
Hypnum cupressiforme, G; cupressiforme var. minus, T.
Ctenidium molluscum, G.
Rhytidiadelphus triquetrus, G, T; squarrosus, G; loreus, G.
Hylocomium splendens, G, T.

HEPATICS.

Marchantia polymorpha, G.
Metzgeria furcata, G.
Pellia fabbroniana, G, T.
Plagiochila, asplenioides, G.
Lophocolea cuspidata, G.
Cephalozia bicuspidata, G.
Calypogeia trichomanis, G.
Lepidozia reptans, G, T.
Diplophyllum albicans, G, T.

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ROLL

OF

THE BOTANICAL SOCIETY OF EDINBURGH.

Corrected to May 1955.

Patron :

HER MAJESTY QUEEN ELIZABETH THE QUEEN MOTHER.

HONORARY FELLOWS.

BRITISH SUBJECTS (LIMITED TO TWELVE).

Date of Election.	
Nov. 1950.	HIS ROYAL HIGHNESS THE DUKE OF EDINBURGH.
Dec. 1945.	Gilmour, J. S. L., M.A., F.L.S., *Cory Lodge, Hills Road, Cambridge.*
April 1938.	Gussow, Hans Theodor, LL.D., F.R.S.C., *Cadboro Bay, Victoria, B.C., Canada.*
Dec. 1945.	Harland, S. C., D.Sc., F.R.S., *Botany Department, University of Manchester.*
Dec. 1945.	Hutchinson, John, F.R.S., LL.D., F.L.S., "*Heatherbank*", *Ambleside Road, Lightwater, nr. Bagshot, Surrey.*
Dec. 1930.	Lang, William Henry, M.B., C.M., D.Sc., F.R.S., *late Barker Professor of Cryptogamic Botany, University of Manchester.*
April 1938.	Pole Evans, Illtyd Buller, C.M.G., M.A., D.Sc., *Irene, Transvaal, South Africa.*
May 1942.	Ramsbottom, John, O.B.E., M.A., Dr.Sc., F.L.S., 34 *Innerdale Road, Richmond, Surrey.*
April 1938.	Salisbury, Sir Edward James, C.B.E., D.Sc., F.R.S., *Royal Botanic Gardens, Kew, Richmond, Surrey.*

FOREIGN (LIMITED TO TWENTY-FIVE).

Oct. 1935.	Clausen, Dr. Jens, *Carnegie Institute of Washington, Division of Plant Biology, Stanford University, California, U.S.A.*
Dec. 1945.	Eames, A. J., Ph.D., *Professor of Botany, Cornell University, Ithaca, N.Y., U.S.A.*
Dec. 1945.	Erdtman, Dr. G., *Palynological Laboratory, Ranh* 22, *Bromma, Sweden.*
Mar. 1950.	Gäumann, Professor Ernst, *Federal Technical High School, Zurich, Switzerland.*
May 1947.	Henry, Mrs. Norman, *Gladwyne, Pennsylvania, U.S.A.*
Mar. 1950.	Hulten, Dr. Eric, *State Museum of Natural History, Botanical Department, Stockholm, Sweden.*
Apr. 1938.	Humbert, Professor H., *Museum of Natural History*, 55 *rue Cuvier, Paris.*
Mar. 1950.	Jessen, Professor Knud, *Botanic Garden, Copenhagen, Denmark.*
June 1923.	MacDougal, Dr. D. T., R.F.D., 170 *Carmel, California, U.S.A.*
Dec. 1945.	Merrill, E. D., M.Sc., Ph.D., *Director, Arnold Arboretum, Jamaica Plain, Massachusetts, U.S.A.*
Mar. 1950.	Muntzing, Professor Arne, *Genetical Institute, Lund, Sweden.*
Mar. 1950.	Nannfeldt, Professor J. A., *University of Uppsala, Sweden.*
Mar. 1950.	Nordhagen, Professor Rolf, *Universitetets Botaniske Museum, Oslo, Norway.*
June 1923.	Osterhout, Professor W. J. V., *Rockefeller Institute*, 66*th Street and Avenue A, New York, U.S.A.*
Mar. 1950.	Skottsburg, Professor C., *Goteborg, Sweden.*

Date of Election.	
Mar. 1950.	Smith, Dr. H., *University Botanical Museum, Uppsala, Sweden.*
April 1938.	Svedelius, Professor N. E., *The University, Uppsala, Sweden.*
Mar. 1934.	Turesson, Professor G. W., *Ultuna, Uppsala 7, Sweden.*
Dec. 1945.	Verdoorn, Frans, Ph.D., *Chronica Botanica Co., Waltham, Massachusetts, U.S.A.*
Oct. 1935.	Westerdijk, Dr. Joh, *Professor of Phytopathology, Utrecht and Amsterdam, Javalaan* 4, *Baarn, Holland.*

ORDINARY FELLOWS.

* *Indicates Fellows who have compounded for Annual Contribution.*

Date of Election.	
Dec. 1953.	Acheson, Miss M. E., B.Sc., Ph.D., *Department of Botany, University College, Dundee.*
Dec. 1915.	Adam, Robert Moyes, F.L.S., *Greystones, Kingussie, Inverness-shire.*
Mar. 1953.	Agnew, A. D. Q., *University College of North Wales, Bangor.*
Nov. 1924.	*Alcock, Mrs. N. L., M.B.E., F.L.S., 108 *Colebrooke Street, Winchester.*
Oct. 1947.	Allan, Sir Robert, 41 *North Castle Street, Edinburgh*, 2.
Oct. 1948.	Allen, J. D., B.Sc., *Oil Palm Research Station, Benin, Nigeria.*
April 1954.	Alltoft, Joseph A., 12 *rue Jean du Bellay, Paris* IV^e.
Nov. 1926.	*Anthony, John, M.C., M.A., B.Sc., 120 *Trinity Road, Edinburgh*, 5.
Oct. 1948.	Aytoun, R. S. C., B.Sc., 18 *Sefton Paddock, Stoke Poges, Bucks.*
Oct. 1948.	Balfour, Mrs. E. J., *Newton Hall, Windygates, Fife.*
Oct. 1949.	Balfour, A. P., F.L.S., A.H.R.H.S., "*Cranford*", *Peppard Common, by Henley-on-Thames, Oxon.*
Jan. 1951.	Balfour Browne, Mrs. F. L., *British Museum (Natural History), Cromwell Road, London, S.W.* 7.
Oct. 1951.	Bange, Christophe, 24 *rue Grenette, Lyons* II^e, *France.*
Feb. 1949.	Banks, J., 34 *Springfield Road, Mannofield, Aberdeen.*
Feb. 1942.	Barnett, Miss E. C., D.Sc., 48 *Albury Road, Aberdeen.*
April 1944.	Beattie, F. F., *Rural Route No.* 3, *Dundas, Ontario, Canada.*
Oct. 1949.	Beattie, Miss E., 9 *West Maitland Street, Edinburgh*, 12.
Mar. 1951.	Bell, J., 4 *Corstorphine Bank Terrace, Edinburgh*, 12.
Dec. 1950.	Bertram, Miss E. D., 22 *Belgrave Crescent, Edinburgh.*
May 1891.	*Berwick, Thomas, 56 *North Street, St. Andrews, Fife.*
Oct. 1952.	Black, William, Ph.D., 204 *Colinton Road, Edinburgh*, 11.
Oct. 1952.	Black, W. A. P., D.Sc., *Seaweed Research Institute, Inveresk, Midlothian.*
Oct. 1945.	*Blackburn, Miss K. B., D.Sc., *King's College, Newcastle-upon-Tyne.*
Feb. 1919.	Blackburne, C. I., *Weydown Hatch, Haslemere, Surrey.*
Jan. 1951.	Blackler, Dr. H., *The University, St. Andrews, Fife.*
Oct. 1946.	Blyth, W., B.Sc., Ph.D., *Royal Botanic Garden, Edinburgh*, 4.
Mar. 1927.	*Boyd, Miss Lucy, D.Sc., 3 *West Brighton Crescent, Portobello, Edinburgh.*
Oct. 1935.	Braid, Professor K. W., M.A., B.Sc., "*Dunalistair*", 22 *Buchanan Street, Milngavie.*
April 1955.	Britten, H., 21 *Tollers Lane, Old Coulsden, Surrey.*
June 1953.	Brook, A. F., Ph.D., *Brown Trout Research Laboratory, Pitlochry, Perthshire.*
May 1924.	*Brown, Miss Helen M., *Longformacus, Duns.*
Oct. 1949.	Brownlie, J. C., *Room* 72, *St. Andrew's House, Edinburgh*, 1.
Dec. 1906.	*Bryce, George, D.Sc., c/o Union Bank of Scotland, 64 *George Street, Edinburgh*, 2.
April 1926.	Buchan, The Right Hon. The Earl of, *World's End Farm, Chobham, Surrey.*
Dec. 1921.	*Burns, W., C.I.E., D.Sc., F.R.S.E., 29 *Craiglea Drive, Edinburgh*, 10.
Dec. 1924.	*Burt, Miss C. C., B.Sc., 36 *Ravenshaugh Road, Levenhall, Musselburgh.*
Oct. 1951.	Burtt, B. L., B.Sc., F.L.S., *Royal Botanic Garden, Edinburgh*, 4.
Feb. 1941.	*Callen, Eric O., B.Sc., Ph.D., *Macdonald College, Quebec, Canada.*
Oct. 1946.	*Cameron, D., B.Sc., *Scottish Society for Research in Plant Breeding, Pentlandfield, Roslin, Midlothian.*
Oct. 1937.	Campbell, Miss M., F.L.S., F.R.G.S., *Easter Tegarmuchd, by Aberfeldy, Perthshire.*
Jan. 1935.	Chen, Feng-hwai, *Botanical Institute of Academia Sinica, Peking, China.*
April 1945.	*Clark, W. A., B.Sc., Ph.D., *Department of Botany, King's College, Newcastle-upon-Tyne.*
Dec. 1928.	Clarke, R. R., B.Sc., *Whitehall, Aberdour, Fife.*
Jan. 1947.	Cockerham, G., Ph.D., *Scottish Society for Research in Plant Breeding, Pentlandfield, Roslin, Midlothian.*

Date of Election.	
Nov. 1954.	Connor, Miss H. M., 28 *Greenbank Drive, Edinburgh*, 10.
Oct. 1950.	Conway, Dr. E., *Department of Botany, The University, Glasgow, W.* 2.
April 1913.	*Cooper, R. E., 40 *Grosvenor Road, Westcliff, Essex.*
Jan. 1952.	Corke, A. T. K., *Long Ashton Research Station, The University, Bristol.*
Jan. 1946.	Coutts, W. L., 2 *Balgonie Place, Markinch, Fife.*
Oct. 1930.	*Cowan, John M., C.B.E., D.Sc., *Inverewe, Poolewe, Ross-shire.*
Feb. 1923.	*Cox, E. H. M., *Glendoick, Glencarse, Perthshire.*
Oct. 1950.	Crawford, Miss J., 18 *Greenbank Drive, Edinburgh*, 10.
Jan. 1952.	Currie, A., 134 *Brunton Gardens, Edinburgh*, 7.
Jan. 1922.	*Dales, Mrs. H., M.A., B.Sc., *Kempcairn*, 140 *Kensington Road, Knock, Belfast.*
Oct. 1926.	*Davey, V. E. M., B.Sc., Ph.D., *Scottish Society for Research in Plant Breeding, Pentlandfield, Roslin, Midlothian.*
April 1948.	Davidian, H. H., B.Sc., *Royal Botanic Garden, Edinburgh*, 4.
April 1950.	Davidson, Dr. James, *Linton Muir, West Linton.*
Dec. 1903.	*Davidson, J. Randolph, M.A., B.Sc., 25 *Meadway Court, Golders Green, London, N.W.* 11.
Dec. 1911.	*Davidson, John, Emeritus Professor of Botany, *Braeriach*, 2119 *West 42nd Avenue, Vancouver* 13, *B.C., Canada.*
Feb. 1950.	Davidson, T. M. W., B.Sc., *Plant Pathology Station, East Craigs, Corstorphine, Edinburgh*, 12.
Mar. 1946.	Davis, P. H., B.Sc., Ph.D., F.R.S.E., 14 *Warrender Park Road, Edinburgh.*
Nov. 1948.	Debney, E. W., B.Sc., Ph.D., 16 *Howes Place, Huntingdon Road, Cambridge.*
Nov. 1927.	*Dobson, Miss M. G., 8 *Polwarth Terrace, Edinburgh*, 11.
Jan. 1951.	Dodds, James G., *Royal Botanic Garden, Edinburgh*, 4.
April 1949.	Dovaston, Dr. H. F., *West of Scotland Agricultural College, Auchincruive, Ayr.*
Nov. 1919.	*Downie, Miss D. G., B.Sc., Ph.D., *Department of Botany, The University, Aberdeen.*
Oct. 1944.	*Duncan, Miss Ursula, *Parkhill, Arbroath.*
April 1940.	Dunn, Miss Mary, B.Sc., Ph.D., 8 *Whitehill Terrace, St. Andrews.*
Dec. 1954.	Dunnett, J. M., B.Sc., *Scottish Society for Research in Plant Breeding, Pentlandfield, Roslin, Midlothian.*
Dec. 1949.	Edwards, M. V., 9 *Braid Crescent, Edinburgh*, 10.
Feb. 1917.	*Eley, Charles, *East Bergholt Place, Suffolk.*
Oct. 1948.	Erskine, D. S. E., B.Sc., *The Saughs, Newtongrange, Midlothian.*
Dec. 1905.	*Evans, W. Edgar, B.Sc., 38 *Morningside Park, Edinburgh*, 10.
Dec. 1927.	*Fenton, Dr. E. Wyllie, *Knowehead, Milltimber, Aberdeenshire.*
Oct. 1943.	Ferguson, Miss E. A. K., B.Sc., 7 *Comely Bank, Edinburgh*, 4.
Oct. 1949.	Finlay, Major Knox, *Keillour Castle, Methven, Perthshire.*
Oct. 1934.	*Fleming, G. J., *Greenwells, Lauder, Berwickshire.*
Dec. 1934.	*Fletcher, H. R., Ph.D., D.Sc., F.R.S.E., *Royal Botanic Garden, Edinburgh*, 4.
Oct. 1928.	Foister, C. E., B.A., Ph.D., *The Croft*, 9 *Hillview Terrace, Edinburgh*, 12.
Oct. 1920.	*Galloway, R. Angus, M.C., B.Sc., 65 *Cluny Gardens, Edinburgh*, 10.
Oct. 1947.	*Galt, R. W. C., B.Sc., *W.A.I.F.O.R. Substation, Njala, via Mano, Sierre Leone.*
Oct. 1946.	Gimingham, C. H., B.A., Ph.D., *Botany Department, The University, Aberdeen.*
Oct. 1936.	*Gordon, Professor H. D., *Botany Department, Victoria University College, Wellington, New Zealand.*
Oct. 1944.	Gorrie, R. Maclagan, D.Sc., F.R.S.E., *Balnagowan, Murrayfield Drive, Edinburgh*, 12.
Feb. 1944.	*Gray, Miss E., Ph.D., *North of Scotland College of Agriculture*, 41½ *Union Street, Aberdeen.*
Jan. 1923.	*Gray, J. H., M.A., B.Sc., 28 *W. Relugas Road, Edinburgh*, 9.
Oct. 1952.	*Green, Peter S., B.Sc., F.L.S., *Royal Botanic Garden, Edinburgh*, 4.
Jan. 1926.	Gregor, James W., Ph.D., D.Sc., F.L.S., *Old Mill House, Balerno.*
Nov. 1954.	Grierson, A. J. C., B.Sc., *Royal Botanic Garden, Edinburgh*, 4.
Mar. 1925.	*Grieve, Miss J. E., *The Latch, Marine Parade, North Berwick.*
Dec. 1948.	Handyside, W., 53 *Viewforth, Edinburgh*, 10.
Jan. 1951.	Harper, Peter C., B.Sc., *Botany Department, Edinburgh, and East of Scotland College of Agriculture*, 13 *George Square, Edinburgh*, 8.
Dec. 1923.	*Harris, Mrs. K., B.Sc., *Oakleigh, Elm Road, Early, Reading.*
Dec. 1946.	Harrison, J. Heslop, B.Sc., Ph.D., F.R.S.E., *Department of Botany, Queen's University, Belfast.*
April 1945.	Harrison, Professor J. W. Heslop, D.Sc., F.R.S., *Cavarnie, The Avenue, Birtley, Co. Durham.*
April 1910.	*Harvey, Miss Elsie, *Kerala, Captain's Road, Edinburgh*, 9.

Date of Election.	
Oct. 1947.	Hay, Miss M. J., B.Sc., 22 *St. Clair Terrace*, *Edinburgh*, 10.
Dec. 1929.	Heddle, R. G., M.A., B.Sc., *Edinburgh and East of Scotland College of Agriculture*, 13 *George Square*, *Edinburgh*, 8.
Nov. 1954.	Hedge, I. C., B.Sc., *Royal Botanic Garden*, *Edinburgh*, 4.
Oct. 1948.	Henderson, D. M., B.Sc., *Royal Botanic Garden*, *Edinburgh*, 4.
Oct. 1947.	Heywood, V. H., B.Sc., Ph.D., *The Botany School*, *Cambridge University.*
Oct. 1926.	*Home, Miss Logan, *Silverwells*, *Coldingham.*
Oct. 1949.	Honeyman, Mrs. H. M., 34 *London Street*, *Edinburgh.*
May 1953.	Hunter, R. T., C.A., *c/o McLaren & Gavin*, 5 *Alva Street*, *Edinburgh*, 2.
Dec. 1953.	Hunter, R. T., B.Sc.(Agric.), Ph.D., 19 *Warrender Park Crescent*, *Edinburgh*, 9.
Oct. 1931.	*Jeffers, R. H., N.D.H., F.L.S., 42 *Archery Road*, *Eltham*, *London*, *S.E.* 9.
Dec. 1935.	*Johnson, J. W. H., C.A., 12 *Granby Road*, *Edinburgh*, 9.
Dec. 1946.	Johnstone, R. H., M.A., 726 *Anniesland Road*, *Glasgow*, *W.* 4.
Oct. 1949.	Keenan, J., *Royal Botanic Garden*, *Edinburgh*, 4.
Jan. 1913.	*Kemp, Mrs. C. Norman, M.A., D.Sc., *Ivy Lodge*, *Laverockbank*, *Edinburgh*, 5.
Oct. 1949.	Kemp, E. E., N.D.H., D.Inst.P.A., *Royal Botanic Garden*, *Edinburgh*, 4.
Oct. 1947.	Kerr, Allen, B.Sc., *Waite Institute*, *University of Adelaide*, *Australia.*
Dec. 1938.	Kidd, Maurice G., B.L., W.S., 13 *Melville Street*, *Edinburgh*, 3.
Nov. 1924.	*King, Miss C. A., *Osborne Nursery House*, *Roseburn Place*, *Edinburgh*, 12.
Oct. 1921.	*King, Miss I. M., B.Sc., 5 *Knowelea Terrace*, *Craigie*, *Perth.*
Jan. 1924.	*Knox, Mrs. J., M.A., D.Sc., 43 *Dalhousie Tarrace*, *Edinburgh*, 10.
Nov. 1948.	de Kock, P. C., M.Sc., D.Phil., *Department of Botany*, *Aberdeen University.*
Nov. 1921.	*Laing, Dr. E. V., 47 *Anderson Drive*, *Aberdeen.*
Dec. 1911.	*Lamont, Miss A., M.A., B.Sc., *Inverchaolin*, *Toward*, *Argyllshire.*
April 1955.	Lanfranco, G. G., 3 *New Street*, *Sliema*, *Malta.*
Oct. 1949.	Lauener, L. A., *Royal Botanic Garden*, *Edinburgh*, 4.
Dec. 1922.	*Lewis, H. M., B.Sc., *Westwood*, *Gresford*, *nr. Wrexham*, *Denbighshire.*
Nov. 1922.	*McCall, David, B.Sc., Ph.C., *Pharmaceutical Society*, 36 *York Place*, *Edinburgh.*
Feb. 1933.	Macdonald, James A., B.Sc., Ph.D., D.Sc., F.R.S.E., *Botany Department*, *St. Andrews University.*
May 1936.	*Macdonald, Miss Mary M., B.Sc., 23 *Glencairn Crescent*, *Edinburgh*, 12.
Dec. 1925.	*McIntosh, A. E. S., B.Sc., Ph.D., *Ashgrove*, *St. Leonards Road*, *Forres*, *Moray.*
Dec. 1950.	McIntosh, Dr. T. P., *Seed Testing Station*, *East Craigs*, *Edinburgh*, 12.
Jan. 1946.	Mackechnie, R., B.Sc., 9 *Skirving Street*, *Shawlands*, *Glasgow*, *S.* 1.
June 1945.	Maclachlan, Mrs. S. H., *Leewood House*, *Dunblane.*
Feb. 1954.	*Macleay, Dr. K. N. G., *Department of Botany*, *University College of Khartoum*, *Sudan.*
Oct. 1947.	MacLeod, Miss A. M., B.Sc., Ph.D., *Heriot-Watt College*, *Edinburgh*, 1.
Dec. 1952.	McVean, D. N., B.Sc., 6 *Dick Place*, *Edinburgh*, 9.
Oct. 1948.	Malcolmson, Miss J. F., B.Sc., Ph.D., *c/o University of Nottingham*, *School of Agriculture*, *Sutton Bonington*, *Loughborough*, *Lancs.*
Oct. 1949.	Marshall, Mrs. Sheila M., B.Sc., *Biological Research Department*, *Pest Control Ltd.*, *Bourne*, *Cambridge.*
Oct. 1914.	*Martin, Miss Isa H., *Newbattle House*, *Pitsligo Road*, *Edinburgh.*
Mar. 1913.	*Matthews, Professor James, *Department of Botany*, *Aberdeen University.*
Dec. 1916.	*Maxwell, Sir John Stirling, Bart., *Pollok*, *Pollokshaws*, *Glasgow.*
April 1919.	*Mills, A. E., 37 *High Street*, *Keynsham*, *nr. Bristol.*
Jan. 1949.	Milne, Miss L. I., *Brierbank*, *Eskbank*, *Midlothian.*
April 1955.	Milne, Dr. James, 2 *Hillview Road*, *Edinburgh*, 12.
Nov. 1949.	Montgomerie, Miss I. G., B.Sc., *Scottish Horticultural Research Institute*, *c/o West of Scotland Agricultural College*, *Auchincruive*, *Ayr.*
Feb. 1953.	Morris, David J., 362 *Morningside Road*, *Edinburgh*, 10.
April 1955.	Morton, Dr. J. K., *Department of Botany*, *University College of the Gold Coast*, *Achimota*, *Gold Coast.*
May 1947.	Muirhead, Miss C. W., *Royal Botanic Garden*, *Edinburgh*, 4.
Dec. 1923.	*Nelson, A., Ph.D., D.Sc., *Royal Botanic Garden*, *Edinburgh*, 4.
Oct. 1943.	Newton, Professor Lily, M.Sc., Ph.D., *University College of Wales*, *Aberystwyth*, *Wales.*
Nov. 1953.	Nimmo, J. A. D., *Glen Esk*, *Eskbank*, *Midlothian.*
Feb. 1944.	*Noble, Miss Mary, B.Sc., Ph.D., 19A *Willowbrae Avenue*, *Edinburgh*, 8.
Oct. 1937.	*Paget, Lady, *Moyne-na-Vey*, *Ballater*, *Aberdeenshire.*
Jan. 1951.	Paterson, Mrs. E. F., 6 *Queensferry Terrace*, *Edinburgh*, 4.
Oct. 1914.	*Patton, Donald, M.A., B.Sc., Ph.D., 15 *Jordanhill Drive*, *Glasgow*, *C.* 3.
Dec. 1917.	*Pike, J. Lydford, M.A., B.Sc., *Rosetta*, 56 *Kirkbrae*, *Edinburgh*, 9.
Jan. 1915.	*Pinkerton, A. A., S.S.C., 10 *Castle Terrace*, *Edinburgh*, 1.

Date of Election.	
Oct. 1937.	Pollock, Sir J. Donald, Bart., O.B.E., LL.D., M.D., *Manor House, Boswall Road, Edinburgh*, 5.
Feb. 1954.	Poore, Duncan, B.Sc., *Nature Conservancy*, 12 *Hope Terrace, Edinburgh*, 9.
Dec. 1944.	Preece, Professor I. A., D.Sc., Ph.D., *Heriot-Watt College, Edinburgh*, 1.
Dec. 1947.	Purves, Miss D. E., *Royal Botanic Garden, Edinburgh*, 4.
Oct. 1947.	Raven, J. E., M.A., *Trinity College, Cambridge.*
Dec. 1932.	Redman, Miss A. W. H., 30 *Lomond Road, Edinburgh*, 5.
June 1952.	Reid, Miss J. B. R., *Fettes Rise, East Fettes Avenue, Edinburgh*, 4.
Oct. 1950.	*Ribbons, B. W., B.Sc., *Department of Botany, Glasgow University.*
Feb. 1952.	Richardson, W. D., B.Sc., *Seaweed Research Institute, Inveresk, Midlothian.*
Jan. 1946.	*Rob, Miss C. M., *Catton Hall, Thirsk, Yorks.*
Mar. 1944.	*Roberts, J., B.Sc., F.L.S., 16 *St. Bernard's Row, Edinburgh*, 4.
Oct. 1946.	Robertson, Mrs. E., B.Sc., *University College of the West Indies, Department of Botany, Mona, St. Andrew, Jamaica, British West Indies.*
Dec. 1944.	Robertson, Noel F., Ph.D., *Botany School, Downing Street, Cambridge.*
Jan. 1951.	Robson, N. K. B., B.Sc., *Royal Botanic Garden, Edinburgh*, 4.
Feb. 1942.	Roger, J. G., B.Sc., F.L.S., 4 *Granby Road, Edinburgh*, 9.
Feb. 1938.	Russell, Sir David, LL.D., F.L.S., *Rothes, Markinch, Fife.*
Oct. 1942.	*Russell, Lady D., *Rothes, Markinch, Fife.*
May 1945.	*Salvesen, H. K., M.A., F.R.S.E., *Inveralmond, Cramond, Midlothian.*
Oct. 1947.	Salzen, Mrs. E., B.Sc., Ph.D., *Nature Conservancy*, 12 *Hope Terrace, Edinburgh*, 9.
Mar. 1935.	*Sandilands, James, Ph.D., F.R.I.C., F.R.S.E., 102 *Westholme Gardens, Musselburgh, Midlothian.*
Feb. 1932.	*Scarlett, R. L., O.B.E., C.D.A., *Sweethope, Musselburgh, Midlothian.*
Dec. 1887.	*Scott, J. S., 69 *Clowes Street, West Gorton, Manchester.*
Mar. 1951.	Seaton, R. D., B.Sc., *Seed Testing Station, East Craigs, Edinburgh*, 12.
Oct. 1947.	Sherriffs, Professor W. Rae, 27 *Park Avenue, Edinburgh.*
Feb. 1940.	*Simpson, John B., D.Sc., *The Shenval*, 6 *Seabank Gardens, Nairn.*
Oct. 1944.	Simpson, N. D., M.A., F.L.S., F.R.M.S., *Maesbury*, 3 *Cavendish Road, Bournemouth.*
April 1940.	*Sinclair, James, B.Sc., *Herbarium, Botanic Garden, Singapore.*
Dec. 1948.	Sloan, A. W., 33 *Plewlands Gardens, Edinburgh*, 10.
Oct. 1939.	Small, Professor James, D.Sc., F.R.S.E., 5 *Eden-a-Grena, Randal Park, Belfast, N. Ireland.*
Oct. 1953.	Smart, Mrs. C. I., *Greengables, Limekilns, Dunfermline, Fife.*
June 1954.	Smith, John, D.Sc., *Birkhill, Coalburn, Lanark.*
Nov. 1914.	*Smith, J. L. S., M.A., B.Sc., 29 *Wardie Road, Edinburgh*, 5.
Dec. 1917.	*Smith, J. T., 68 *Tennant Street, Glasgow.*
Oct. 1947.	Smith, Miss M. McLean, 23 *Redburn Avenue, Whitecraigs, Glasgow.*
Jan. 1902.	*Smith, Professor Sir William Wright, LL.D., F.R.S., *Inverleith House, Edinburgh*, 4.
Jan. 1952.	Spence, D. H. N., B.Sc., *Department of Botany, Glasgow University.*
Nov. 1923.	*Stern, F., *Highdown, Goring-on-Sea.*
Oct. 1923.	*Stevenson, J. B., *Tower Court, Ascot.*
Oct. 1914.	*Stewart, E. J. A., M.A., B.Sc., 8 *Manor Road, Jordanhill, Glasgow.*
Dec. 1944.	Stirling, Mrs. A. C., B.Sc., *Department of Bacteriology, Edinburgh and East of Scotland College of Agriculture*, 13 *George Square, Edinburgh*, 8.
Feb. 1952.	Summers, T. W., B.Sc., *Building Research Station, Garston, nr. Watford, Herts.*
Oct. 1952.	Sutcliffe, Miss Alys, *Brooklyn Botanic Garden, Brooklyn* 25, *New York, U.S.A.*
Oct. 1926.	*Taylor, George, D.Sc., *Department of Botany, British Museum, Cromwell Road, London, S.W.* 7.
Dec. 1922.	*Taylor, G. C., B.Sc., c/o R. H. Bath, Ltd., *Wisbech, Cambs.*
May 1923.	*Taylor, James, M.A., B.Sc., *High School, Dalbeattie, Kirkcudbrightshire.*
May 1923.	*Taylor, R. A., D.Sc., *Dyke of Lornie, Errol, Perthshire.*
Oct. 1932.	*Tetley, Miss U., M.Sc., *High Garth, Heathwaite, Windermere, Westmorland.*
April 1921.	*Thompson, Professor J. MacLean, M.A., D.Sc., F.L.S., *Department of Botany, Liverpool University.*
Oct. 1928.	Thompson, J. R., B.Sc., *Seed Testing Station, East Craigs, Edinburgh*, 12.
Oct. 1928.	Thomson, Miss Norah M., 8 *Belgrave Crescent, Edinburgh*, 4.
Oct. 1943.	Todd, J. M., B.Sc., *Seed Testing Station, East Craigs, Edinburgh*, 12.
Oct. 1948.	Valentine, D. H., M.A., Ph.D., *Department of Botany, University Science Laboratories, South Road, Durham.*
May 1950.	Vane, F. R., B.Sc., c/o Mrs. Bruce, 111 *Trinity Road, Edinburgh*, 5.
June 1952.	Waldie, Miss N., 4 *Airlie Place, Edinburgh*, 3.
Mar. 1947.	Walker, F. T., B.Sc., *Seaweed Research Institute, Inveresk, Midlothian.*
Mar. 1932.	Walton, Professor J., M.A., D.Sc., *The University, Glasgow.*
Oct. 1939.	Watson, Dr. E. V., 15 *Ilkley Road, Caversham, Reading.*

Date of Election.	
Oct. 1918.	*Watson, H., B.Sc., *Merchiston, Belle Vue Road, Banff.*
Oct. 1947.	Watson, Miss P. J., M.A., Ph.D., *Scottish Society for Research in Plant Breeding, Pentlandfield, Roslin, Midlothian.*
April 1921.	Watt, Miss Janet, 2 *Catherine Place West, Edinburgh*, 12.
April 1930.	*Watt, Mrs. Menie, F.L.S., 75 *Blackford Road, Edinburgh*, 9.
April 1954.	Webster, Miss M. M., c/o Bank of Scotland, *Macduff, Banff.*
Dec. 1947.	Whiteside, Miss L. M. P., B.Sc., 30 *Torphin Road, Edinburgh*, 13.
Dec. 1930.	*Whyte, J. H., B.Sc., *Botany Department, University of Alberta, Edmonton, Canada.*
Feb. 1912.	*Wilson, Malcolm, D.Sc., *Brent Knoll, Kinnear Road, Edinburgh*, 4.
Mar. 1909.	*Wilson, T., Ph.C., 110 *High Street, Burntisland.*

ORDINARY MEMBERS.

Dec. 1953.	Basden, E. B., 7 *Leyden Park, Bonnyrigg, Midlothian.*
Nov. 1932.	Broadfoot, Miss J., B.Sc., c/o *Lloyd's Bank, Staines, Middlesex.*
Dec. 1954.	Buchanan, Miss J., B.Sc., 29 *Milton Road West, Portobello, Midlothian.*
Dec. 1951.	Chant, S. R., B.Sc., *Imperial College of Tropical Agriculture, Trinidad, British West Indies.*
Nov. 1954.	Connor, Mrs. L. M., 28 *Greenbank Drive, Edinburgh*, 10.
Oct. 1931.	Cunningham, Miss M., 6 *Merchiston Bank Gardens, Edinburgh*, 10.
Jan. 1950.	Derrick, J., *Teviot Cottage, March Street, Peebles.*
Jan. 1940.	Dickson, Miss A. M., *Woodhouse, Dunscore, Dumfries.*
Jan. 1955.	Eggeling, W. J., B.Sc., Ph.D., *Brackness House, Lady Walk, Anstruther, Fife.*
May 1955.	Elliot, Miss Elsie, 2 *East Brighton Crescent, Portobello, Midlothian.*
Jan. 1949.	Elmy, Mrs., c/o Mrs. Pearson, 66 *Polwarth Terrace, Edinburgh*, 11.
Feb. 1954.	England, F. J., B.Sc., *Scottish Society for Research in Plant Breeding, Pentlandfield, Roslin.*
Nov. 1927.	Evans, Miss, 38 *Morningside Park, Edinburgh*, 10.
Feb. 1954.	Harberd, D. J., B.Sc., *Scottish Society for Research in Plant Breeding, Pentlandfield, Roslin.*
Nov. 1932.	Hawkins, Miss K., B.Sc., 33 *Queensferry Street, Edinburgh*, 2.
Mar. 1953.	Hopkins, John, B.Sc., *Royal Botanic Garden, Edinburgh*, 4.
Dec. 1936.	Kennedy, Miss M. C. L. S., B.Sc., 384 *Ferry Road, Edinburgh*, 5.
April 1925.	McIlvenna, W. R., 14 *Inverleith Place, Edinburgh*, 4.
Dec. 1951.	MacKenzie, D. W. R., B.Sc., *Royal Botanic Garden, Edinburgh*, 4.
April 1949.	Millar, Miss C. K. M., 29 *Bruntsfield Gardens, Edinburgh*, 10.
Dec. 1951.	Poulter, Miss B., B.Sc., *Royal Botanic Garden, Edinburgh*, 4.
April 1925.	Smith, Thomas A., 142 *Greenbank Road, Edinburgh*, 10.
Feb. 1954.	Wilkins, D. A., B.Sc., *Scottish Society for Research in Plant Breeding, Pentlandfield, Roslin, Midlothian.*

ASSOCIATE.

Dec. 1945.	Wilkie, David, A.H.R.H.S., *Royal Botanic Garden, Edinburgh*, 4.

LADY MEMBERS.

April 1944.	Anthony, Mrs., 120 *Trinity Road, Edinburgh*, 5.
Dec. 1948.	Benham, Mrs. G., 23 *Morningside Place, Edinburgh*, 10.
Dec. 1944.	Borthwick, Miss J. L., 3 *Learmonth Park, Edinburgh*, 4.
June 1949.	Brockie, Miss J., 13 *Comely Bank Terrace, Edinburgh*, 4.
Dec. 1947.	Burgess, Miss A. L., 30 *Oxgangs Terrace, Edinburgh*, 13.
Dec. 1952.	Burtt, Mrs. B. L., 250 *Ferry Road, Edinburgh*, 5.
Dec. 1926.	Callender, Mrs. C. A., 5 *Inverleith Place, Edinburgh*, 4.
April 1944.	Cameron, Mrs., 20 *Cumin Place, Edinburgh*, 9.
Oct. 1943.	Cattanach, Miss M. M., 25 *Greenhill Gardens, Edinburgh*, 10.
May 1936.	Cowan, Mrs. J. M., *Inverewe, Poolewe, Ross-shire.*
Dec. 1947.	Darling, Mrs. W. N., 48 *Inverleith Place, Edinburgh*, 4.
Feb. 1937.	Fenton, Mrs. E. Wyllie, *Knowehead, Milltimber, Aberdeenshire.*
May 1936.	Fleming, Miss H. B., M.A., *Eastwood, Lauder.*

Date of Election.	
Mar. 1942.	Fletcher, Mrs. H. R., 29 *Howard Place, Edinburgh*, 4.
April 1946.	Gregor, Mrs. Mary, B.Sc., Ph.D., *Old Mill House, Balerno, Midlothian.*
Mar. 1946.	Haldane, Mrs. J. M., 17 *Magdala Crescent, Edinburgh*, 12.
Dec. 1949.	Hamilton, Miss A., 28 *Gillespie Crescent, Edinburgh*, 10.
Dec. 1952.	Ker, Mrs. D., 9 *Lonsdale Terrace, Edinburgh*, 3.
June 1949.	Linsell, Miss E. L., 28 *South Learmonth Gardens, Edinburgh*, 4.
Dec. 1944.	MacColl, Mrs. M. H., 52 *Cloanden Place, Kirkcaldy, Fife.*
Feb. 1953.	Macdonald, Mrs. J. A., 15 *Howard Place, St. Andrews, Fife.*
Jan. 1950.	McIvor, Miss Merle, 16 *Craigleith Hill Gardens, Edinburgh*, 4.
Oct. 1937.	Miller, Mrs. Hugh, 22 *Blackett Place, Edinburgh*, 9.
Feb. 1946.	Miller, Mrs. H. T., 30 *Queensferry Street, Edinburgh*, 2.
Nov. 1950.	Morrison, Miss M. K., M.A., 25 *Greenbank Drive, Edinburgh.*
Dec. 1949.	Reid, Mrs. J. W., 46 *Lockharton Avenue, Edinburgh*, 11.
Feb. 1948.	Sherriffs, Mrs. Rae, 27 *Park Avenue, Portobello, Edinburgh.*
Dec. 1947.	Simpson, Mrs. J. B., *The Shenval*, 6 *Seabank Gardens, Nairn.*
Nov. 1926.	Smith, Lady, *Inverleith House, Edinburgh*, 4.
Feb. 1946.	Stott, Miss E. R., *Morven, Barnton, Midlothian.*

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